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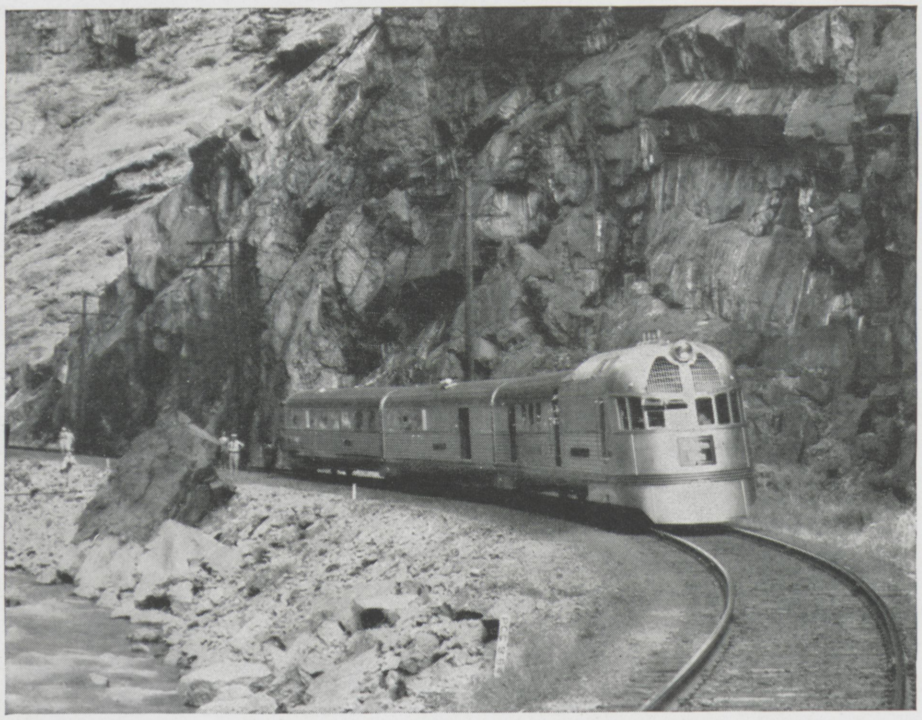
MARKS-'35.



WELDING is responsible for a majority of the streamliners now racing about the country. Burlington's Zephyrs, the Boston & Maine's Flying Yankee—all made of stainless steel—and the Pennsylvania's new super-electric locomotives, all owe their form and much of their efficiency to welding. Welding makes possible tremendous savings in weight without sacrificing strength and rigidity.

Streamlining . . .

Demands smooth, unbroken surface and strong, light frames—both attained by welding

"STREAMLINING" is more than a word to catch popular fancy and assure sales. This design trend, in automobiles, trains, ships and a vast variety of equipment items, has several extremely sound reasons for existence. Smooth mass-distribution and unbroken surfaces mean ease of operation and savings in power for moving objects. This smoothness of design also results in easier handling of portable objects, as well as cleanliness, simplicity and efficiency.

Streamlining involves the method of construction, the theory behind the design. Streamlined articles are unit-built of strong, light materials. The entire product is designed to be one-piece and to develop the maximum strength of each individual member with the minimum of added weight.

Welding is the most practical, least expensive and surest means of attaining permanent strength in metal fabrication. A welded article is a single unit when assembled, and always remains so. There are no mechanical joints to jolt, jar or work loose with the passage of time. Various members can be depended upon to develop their full, assigned reactions now or ten years from now. Welded construction, therefore, means more than adequate economy in design and construction. It means confidence in the permanence and adequacy of the product.

Welding allows the designer to specify any shape or combination of shapes without limitation. By welding, complex forms can be built up from simple units. Metal can be cut away or added. Projections, lugs, ears, rods, bars, any member—can be added to the foundation. Dissimilar metals can be joined. Long-wearing or corrosion-resistant alloys can be used to reinforce or build up at sections subject to special wear or abrasion.

In fact, welding relieves the designer of many limitations, of most of the old inhibitions and joint problems of old-fashioned design. It makes possible the fabrication of a better, more serviceable, longer-lived product at lower cost. The essential advantages of modern design are obtained by welding with convenience, economy and assurance.

Welding Savings

The New Haven "Comet" uses cromansil steel engine beds and car trucks, all welded. Cromansil, a high-tensile mild-alloy steel containing chromium, manganese and silicon, was chosen as best for high-strength, rigid members. Welding was specified because it develops the full strength with minimum weight.

* * *

Stands for automatic vending machines are now stronger, better, more permanent. They used to be made by screwing lengths of 1½-inch pipe into cast iron bases. They are now bronze-welded at less cost with obvious improvement in strength, durability and ease of fabrication.

* * *

Welding makes stainless steel beer barrels practical. Strong, light, smooth inside and out, these barrels have no crevices or corners in which fungi and bacteria can breed. Welding makes them all one-piece and prevents bacterial and mold action and chemical off-tastes. Further, because of welding, they outlast all others.

* * *

Welding produces gas-operated refrigerators at a reasonable production cost. After making exhaustive tests involving every method of fabrication possible, the manufacturer standardized on welding 100 per cent. Results include a better product, more flexibility in design and lower manufacturing costs.

* * *

Welding makes modern metal furniture production possible. Faced with tremendous competition, this new industry capitalized the advantages of welding in the production of light, strong, modern designs and has grown to a sound and healthy state. Welding in this case means mobility in design as well.

* * *

Every day welding is being used in the production of different articles. For instance, an order was recently received for 2000 window display fixtures. Welding was specified because welding permits any design, gives neat appearance and a strong sturdy assembly at low cost.

* * *

Tomorrow's engineers will be expected to know how to take advantage of this modern metalworking process. Many valuable booklets describing the oxy-acetylene process are available without obligation. For further information write any Linde office.

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Surveying This Issue

HAS the economic problem of efficient power transmission been solved? According to authorities in electrical engineering, it has not. In this month's lead article Mr. Carroll suggests constant direct current power transmission as a solution to this problem.

ALTHOUGH the principles of gyroscopic action were known long ago, applications of these principles in solving new problems will never cease. Yet these simple principles continue to mystify even engineering students. In this article Mr. Scharenberg presents a worthwhile discussion of the fundamentals of gyroscopic action.

IN order to meet better the increasing demand for aluminum, its producers are continually on the alert for new methods of manufacture and new applications of the metal. Mr. Christiansen describes four different processes for the commercial preparation of aluminum, giving in detail the actual steps in the most common process.

—M. B. S.

THE ROSE TECHNIC

APRIL 1938

Engineering College Magazines Associated

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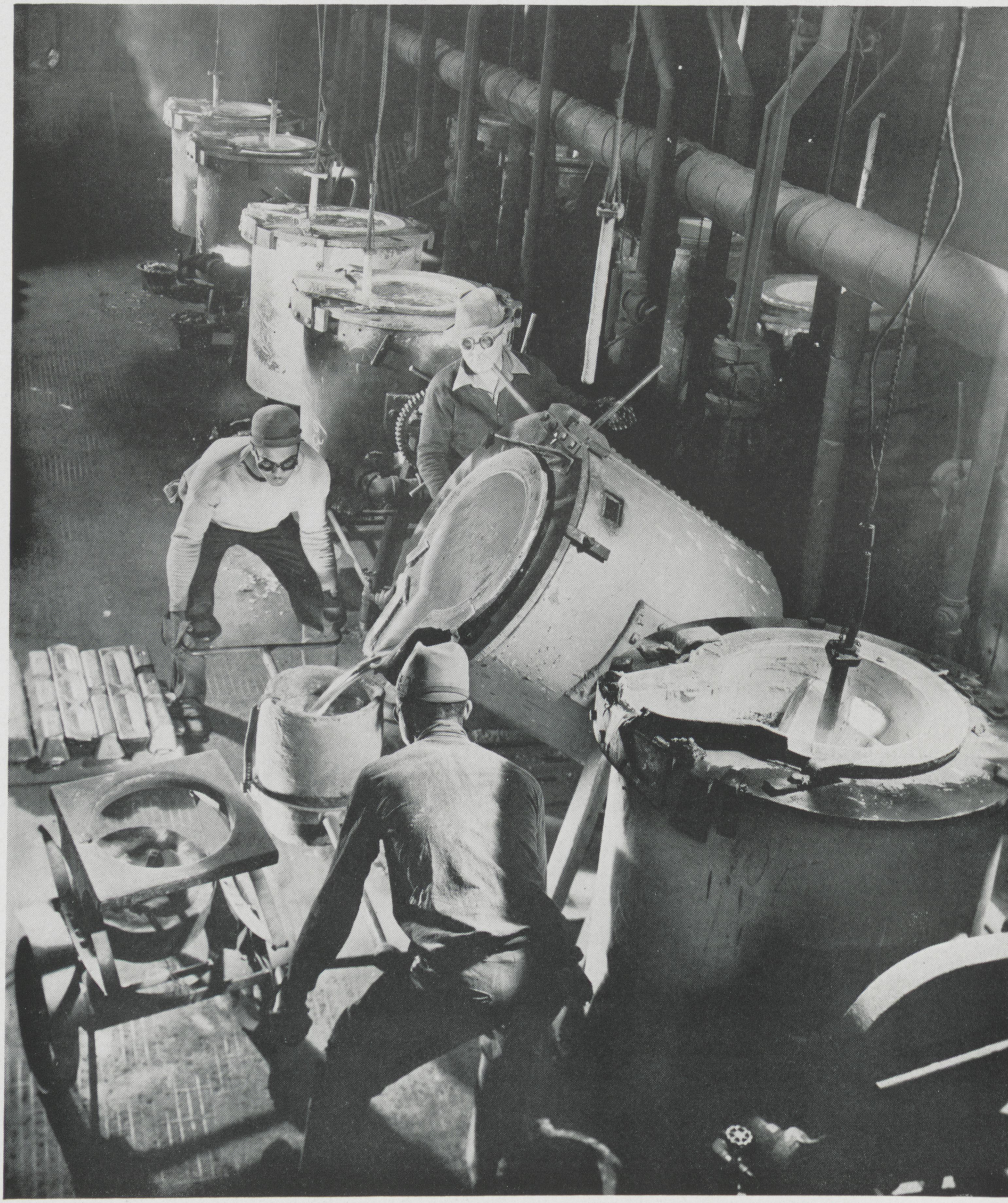
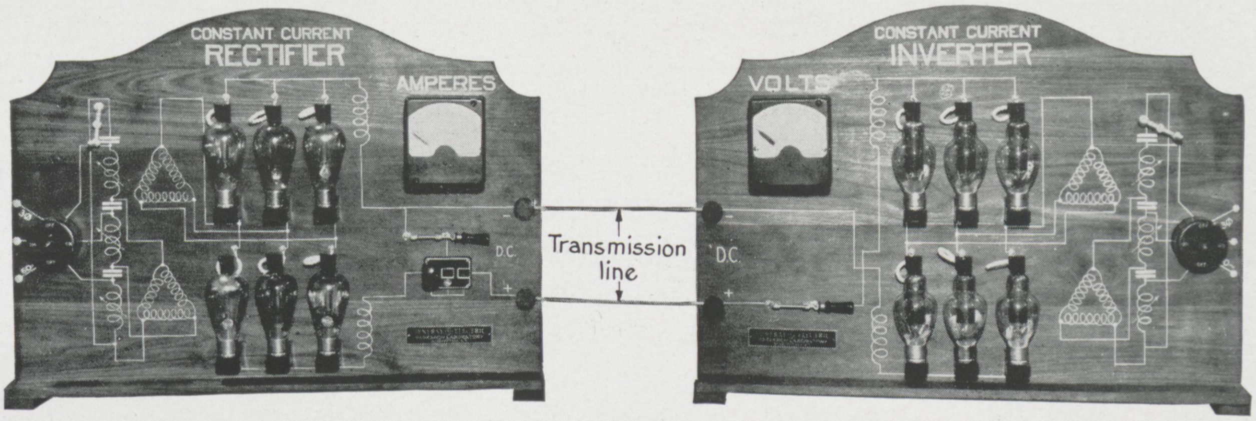


Cut Courtesy Scientific American

Molten Aluminum Being Poured into Graphite Crucibles



Direct Current Power Transmission - - Is It The Answer?

by

Wendell E. Carroll, e., '38

LARGE amounts of power may be most efficiently transmitted by direct currents at high voltages. The engineering difficulties encountered in applying this method of transmission have heretofore been too numerous to make it economically sound. In recent years, however, new instrumentalities have been devised which have led engineers to make a reappraisal of the whole electrical transmission problem.

A simple numerical example will demonstrate that it is necessary to use high voltages for economical energy distribution. If a line is delivering 20 kilowatts at 1000 volts and 20 amperes, and if the resistance of the line is 1.00 ohm, the voltage drop in the line is 20 volts or 2.0 per cent of the total voltage. The corresponding power loss in the line is the current squared times the resistance or 400 watts. This amounts to 2.0 per cent of the power delivered.

If now the line voltage be doubled, the same power may be delivered at 2000 volts with a current of only 10 amperes. Under these conditions the voltage drop will be 10 volts or 0.5 per cent of the load voltage. The power loss corresponding to this condition will be only 100 watts or

Efficiency in power transmission has long been a problem which electrical engineers have never fully solved. In this month's lead article, Mr. Carroll tells of how new investigations have led engineers to rediagnose the whole electrical transmission problem.

0.5 per cent of the power delivered.

From the above example it is seen that by doubling the voltage the loss of the line may be made one fourth of its original magnitude. The economical limit for the increase of voltage is reached when the saving on decreased power loss is offset by the added expense for better insulation.

In the alternating current system, high potentials may be easily obtained by using high ratio transformers. The major objections, however, to alternating current are high impedance drops in the line, power loss in insulation, power factor, and relatively high insulation costs for a given effective voltage.

The need for economical transmission, hence high voltage transmission, is the power engineer's major problem. About 30 years ago a French engineer by the name of Thury designed a system that is still in use between Montiers and Lyons, France.

The Thury System

Thury's arrangement was not an ingenious one, but it was an experiment to investigate d.c. lines under actual conditions, and it permitted the study of the problems involved.

Figure 1 is a schematic representation of the Thury system. In this original generating plant there were four sets of double generators delivering 1,150 k.w. at 14,200 volts per set. This made the total output of the plant 4,600 k.w. Mechanical construction of the generators limited the commutator voltages to 4,600 volts.

The transmission line of the system consisted of 230 miles of overhead line and 45 miles of underground cable. The line was originally a single circuit but has since been enlarged.

To distribute the power transmitted by the lines, several high voltage d.c. motors were put in series and each was used as a prime mover for several low voltage d.c. or a.c. generators. Power was distributed from the small machines.

For thirty years this particular Thury arrangement has functioned, but the faults were soon recognized, and only a few of the systems have since been built.

As previously stated, the allowable commutator voltage is about 4,600 volts. With this condition existing, it is necessary to keep the lower potential of each machine at the highest potential of the machine preceding it in the series circuit. That is, with generator number one of figure 1 generating a voltage of 4,600 volts, the frame of generator number two must operate at a potential of 4,600 volts above ground to prevent arcing at the brushes and breakdown of insulation between the frame and conductors. The last machine of the series circuit is obviously at a very high potential. Therefore, a great expense in both transmitting and receiving stations was incurred for insulating bases and insulating mechanical couplings. The high potentials also make the operation of the power station extremely hazardous.

At present there are many low voltage generators of greater rating than that of the whole station just mentioned. These low voltage generators carry enormous currents and are usually better than 95% efficient. In the station just described mechanical friction prohibits efficiencies of this order.

The Thury system is flexible but is inconvenient in that changing the number of generators in the circuit for accommodating high or low loads is a difficult procedure. The difficulty lies in changing the currents from the short circuiting switch into the idle generator without disturbing the circuit. This procedure will not be explained here.

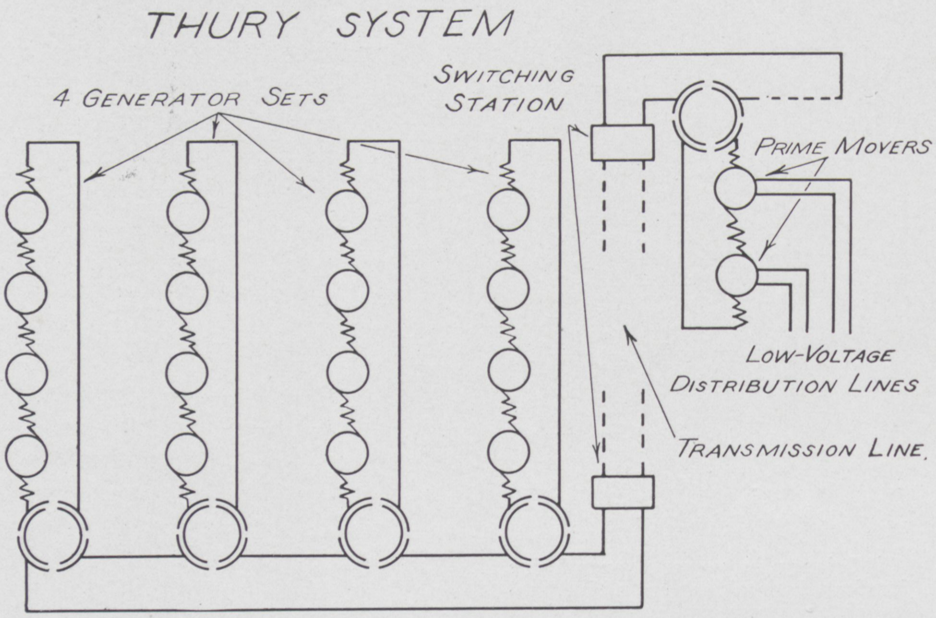


FIG. 1

Solution of the difficulties mentioned above is most nearly approached in a system devised by Dr. C. H. Willis of Princeton University, assisted by B. D. Bedford and F. R. Elder of the General Electric research laboratories. The new scheme takes advantage of the ease with which alternating voltages can be stepped up, then uses constant-current d.c. transmission. The arrangement designed and tested by the above men is represented in the cut on page 3.

Willis, Bedford, and Elder Circuit

The monocyclic network was first studied and used extensively by Steinmetz and was found to be quite useful in circuits where it was necessary to change from constant potential to constant current. In a d.c. transmission arrangement, constant current eliminates the danger of serious damage to the lines and machines when the lines are short circuited.

If capacitive and reactive loads of such characteristic as to make Z_l equal Z_c are connected between two constant potential points, as shown in figure 2a, the load R_1 will then represent a pure resistance to the neutral of the system. Under these conditions, the vector diagram shows the magnitude and phase angle of the load current with respect to voltage E_{ab}.

By adding to R_1 the inductance L_1, a typical load exists and is shown in figure 2b. With L_1 in the circuit, E_{od} leads its current and causes a decrease in E_{ad}. The decrease in E_{ad} correspondingly decreases I_{da}, but $(E_{ad}+E_{db})$ must equal E_{ab} so E_{db} is increased and I_{db} increases accordingly. Now, by the quadrature relation of reactive potentials and currents, the two currents, I_{ad} and I_{db}, still add, and the current through the load is the same as in figure 2a. This constant current relation can be demonstrated mathematically but is beyond the scope of this paper.

It should be noticed that if the load approaches an infinite value, the series circuit of L and C becomes resonant and the voltage across each becomes infinite. In the other extreme if the load impedance becomes zero (short circuited), E_{da} approaches E_{oa}, and E_{db} approaches E_{ob} which causes E_{od} to become zero. This feature of constant current systems renders short circuits harmless. Open circuited conditions will be mentioned later.

On the close examination of figure 2, it will be noticed that the arrangement of the monocyclic network is three arrangements similar to figure 3. This may be more obvious as shown in figure 4 where A-B-C is the three-phase constant voltage network previously shown.

The output of the monocyclic network is introduced into the three-phase Y-connected rectifiers which are shown in figure 3.

Three-Phase Rectifier Operation

The particular rectifiers used in this arrangement are steel-cylinder grid-controlled mercury-arc rectifiers. Mercury-arc rectifiers are unidirectional, i.e., allow current to flow in one direction only, hence are used as shown.

With the arrangement shown, the high potential d.c. is taken from the neutrals of the Y-connected rectifiers. Figure 4a shows relative magnitude of voltages on the rectifiers, and figure 4b illustrates the relative flow of current in each rectifier. Adding the ordinates of figure 4b, it is found that the result is a steady d.c. current flowing from the left neutral to the right one. Figure 3 in conjunction with figure 4 is nearly self-explanatory and should be studied before continuing with the text.

It is very interesting to notice that when full current flows through rectifier (1), the combined currents of rectifiers (2′) and (3′) are exactly equal and are aiding rectifier (1).

Line Reactors

It is, of course, impossible to have an original three phase source made up of perfect sine waves. The result is that harmonics are introduced and the d.c. current has ripples in it. To

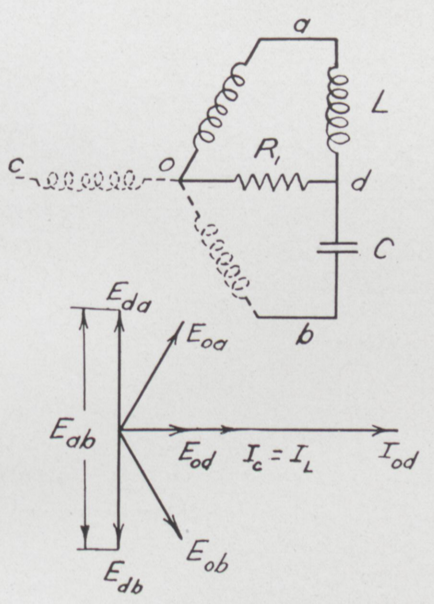


FIG. 2a

suppress these ripples, the small inductances shown in figure 3 are put into the transmission line. Such inductances greatly impede the harmonics and give a more steady d.c. current. Removal of such ripples greatly decreases telephone interference caused by the line.

At the receiving end of the line is a network that greatly resembles the sending end network. The purpose of this part of the arrangement is the exact converse of the sending

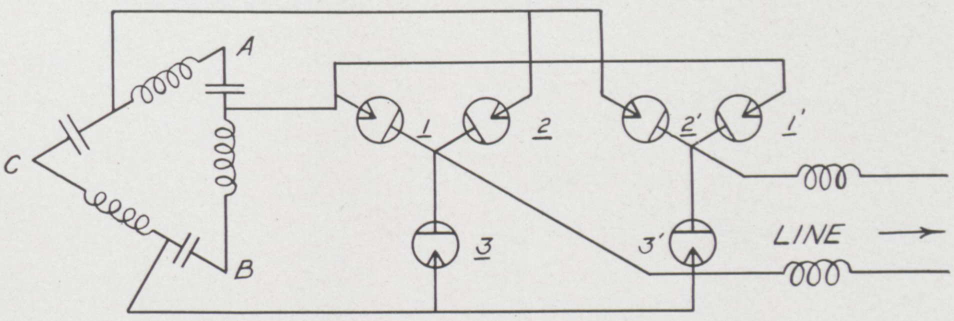


FIG. 3

end. It changes the constant current d.c. to constant current a.c., the constant current a.c. to constant potential a.c., and constant potential a.c. to distributable voltage by the use of transformers.

Inverters

Figure 5 shows two sets of mercury arc rectifiers, Y-connected. In

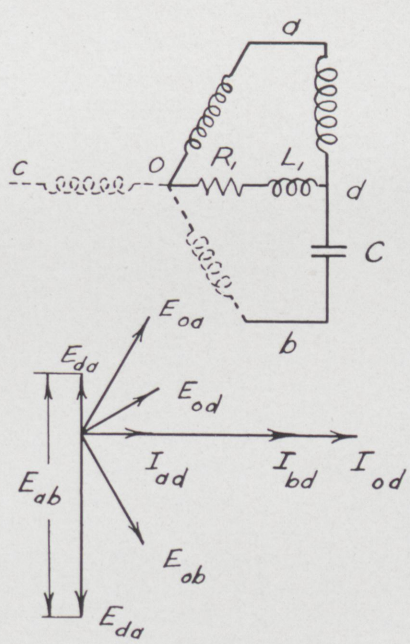


FIG. 2b

actual practice, these inverters are the same as the rectifiers of the sending end.

To understand the conversion of constant current d.c. to constant current a.c., a slight knowledge of the effect of grid potential on plate current is necessary. A positive grid potential (all grid potentials are taken with respect to cathode, i.e., mercury pool) causes electrons to leave the mercury and flow to the anode, while a negative grid potential prevents the flow of electrons.

By closely studying the curves of figure 6 in conjunction with figure 5, one will find the the grid potentials cause current to flow and cause it to cease flowing in just the proper sequence to produce the currents represented in figure 6b.

Receiving End Monocyclic Network:

The receiving end monocyclic network has the inverse duty of the network at the sending end. In the operation of this network, however, the voltage is produced by the load to neutral; see figure 2b. E_{od} is now the independent variable and the other vectors would have the same relations to it, while E_{ab} would be a constant and I_{od} a constant.

Therefore, the output of the receiving end monocyclic network is three-phase and of constant potential.

Circuit Refinements

As yet there has been no reference to power control, but such control is one of the outstanding features of the proposed system. Rectifier output is quite often governed by a negative d.c. bias on the grid; therefore grid bias was the first attempt at load control. This method was not totally unsatisfactory but a better method has been discovered.

The advantages of the second method will be discussed later in this paper.

It can be proved that the current output of one side of the monocyclic network is approximately

$$I = \frac{E}{\sqrt{Z_1 Z_2}},$$

when E is the constant voltage applied and Z_1 Z_2 is the product of the two reactive monocyclic branches. From the equation, the current can be increased by increasing E or decreasing Z_1 Z_2.

Reactor X_1, of figure 7, represents the reactor of one side of the network. As shown, another reactor is put in parallel through phase controlled thyratron switches. By proper control of the grids in the thyratron switches, the parallel arrangement will readily pass an a.c. current, but by shifting the phase of the grid control, the current through X_2 can be varied. This, in effect, varies the reactor value from X_1 to $\frac{X_1 X_2}{X_1 + X_2}$

Overvoltage-Protection

Earlier in this paper it was mentioned that an open circuit on the line would cause immense voltages across the monocyclic elements. Protection against such an occurrence is afforded by spark gaps across the condensers. Under extreme voltages these gaps will break down before the monocyclic elements are affected.

Rectifiers

Because of the unidirectional conductances of the rectifiers, it is not necessary to control them by grids. The inverters, however, have a constant voltage across their elements and their flow must be controlled. At this point it can be seen that the system is completely reversible if grid controls are used to change the rectifiers to inverters.

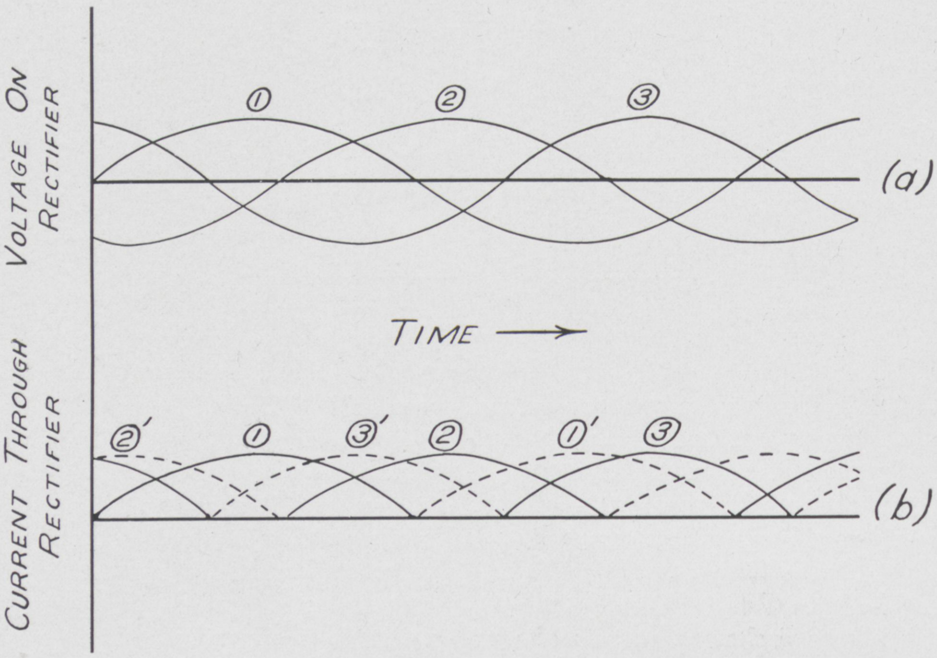
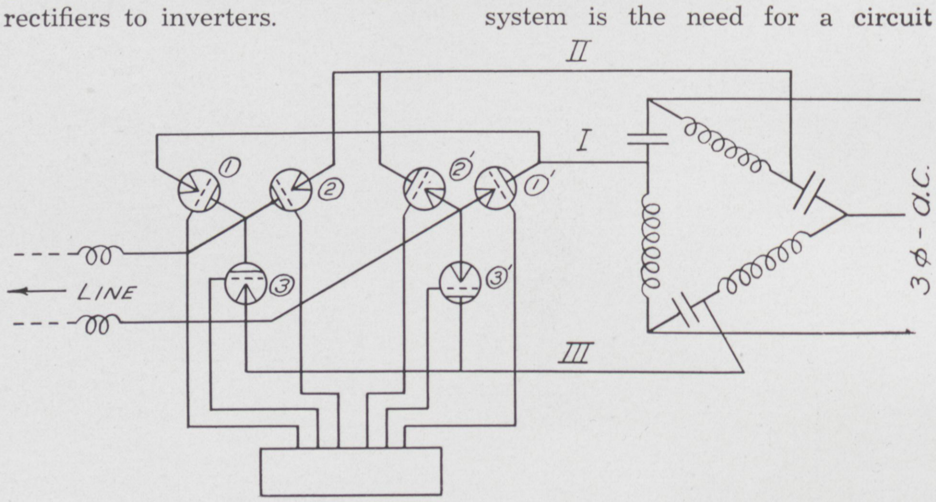


Fig. 4



6Φ - Sine Wave Grid Control

Fig. 5

The following is a summation of the major advantages and disadvantages of the proposed system.

Advantages

1. In connection with the d.c. transmission line, there will be no line voltage drop because of inductance and no voltage rise because of capacitance. Therefore, the only voltage drop will be that caused by resistance of the line.

2. Stability problems of a.c. systems are, of course, eliminated in view of the facts stated above. Also, the frequencies of the transmitting and receiving ends are independent of each other. This independence allows the prime movers to operate at their most efficient speeds. The monocyclic network characteristics will, of course, change with the change in frequency. If, however, the frequency change is slight, the load control network can properly adjust the system.

3. The absence of line reactance eliminates the use of compensating condensers along the line.

4. With d.c. current, there will be no skin effect, hence there will be better utilization of copper and less I^2R loss.

5. In overhead lines, the permissible voltage may be increased by at least 40 per cent, because of the ratio between peak and effective voltage in alternating current.

Disadvantages

1. First of the problems in this system is the need for a circuit breaker capable of interrupting the high voltages used. This problem may be circumvented by doing all switching on the a.c. side of the network.

2. The equipment necessary for

the above system has not as yet been put on a production basis and is, consequently, quite expensive.

3. In the explanation of line reactors, the harmonics in the current were mentioned. Because of these harmonics, the output of the system is not made up of pure sine waves.

Herman Halperin of the Commonwealth Edison Company recently made some calculations to study the possibility of changing some of that company's lines to constant-current d.c. transmission. The following is a summation of his results:

1. On a 4-mile length of 3-conductor 12 k.v. cable, it would be possible to change to 40 k.v. This would result in a change of the capacity of the line from 9,000 k.v.a. to 20,000 k.v.a. To increase the line 11,000 k.v.a. by adding to the present system, would cost about $70,000. To make the conversion, the cost of equipment and maintenance for the d.c. system would therefore have to be less than $70,000.

2. On certain 6 mile lines, a corresponding change in capacity would be from 40,000 k.v.a. to 130,000 k.v.a. The savings would be about $450,000. In this case, the installed cost of equipment and maintenance would need to be less than $450,000.

Mr. Halperin concluded from his calculations that until the cost of such equipment was lowered a conversion would not be economically justified on short distribution lines. These computations, however, are for comparatively short lines and do not bring out the possibilities of long lines.

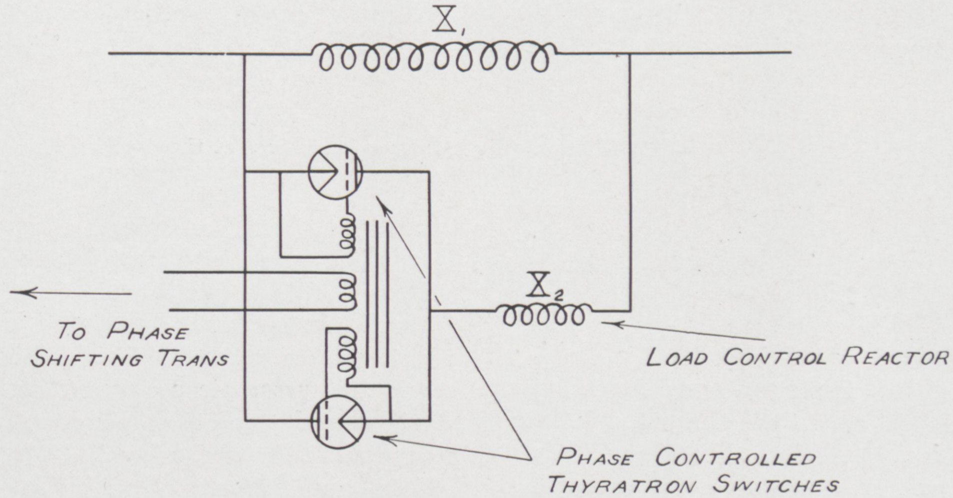


Fig. 7

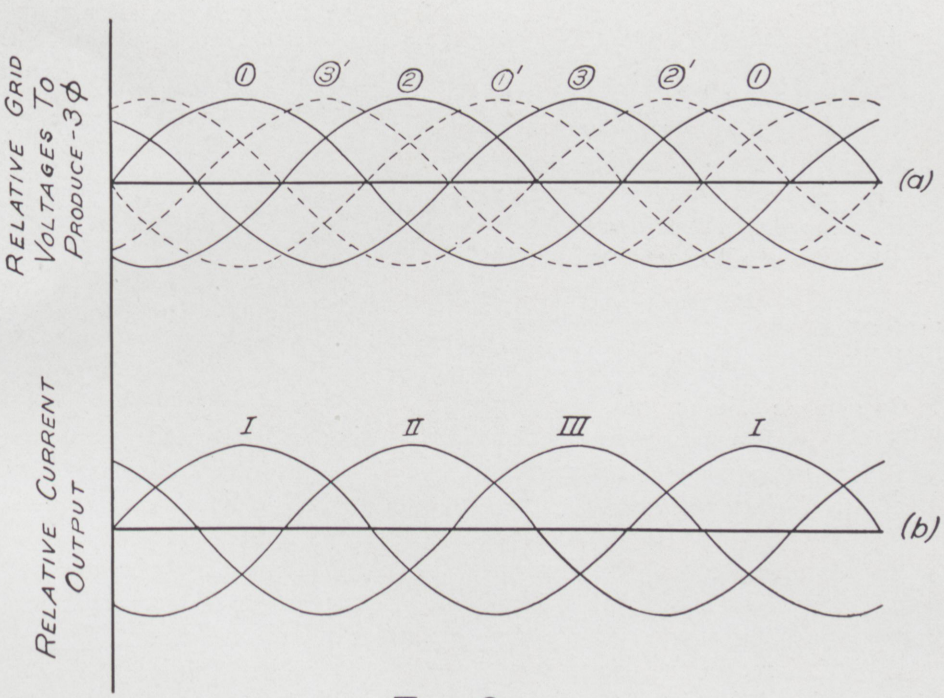


Fig. 6

Conclusion

In conclusion it might be said that constant current d.c. power transmission has great possibilities and that it is definitely more efficient than the present constant potential a.c. system of transmission. However, a change to the d.c. system would result in the obsolescence of valuable a.c. equipment. This is the principal reason for no immediate change. With the present cost of the d.c. equipment, there is no marked decrease in expense, although the saving is fairly large. Therefore, its utilization depends completely on the economic balance between savings and investments. A system for long line transmission is altogether feasible, but as yet the savings on short lines would not permit the change from the existing constant potential a.c. system.

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Fundamentals of Gyroscopic Action

by

Merton B. Scharenberg, m., '38

Even though gyroscopes and gyroscopic action are very common, the average student knows very little of them and their fundamental principles. This action is invaluable if correctly applied and may be extremely dangerous if disregarded. Mr. Scharenberg presents this basic discussion of gyroscopic action in order that these principles may be more easily understood.

THE knowledge of the dynamics of rotary motion and of the mystifying properties of the spinning top or gyroscope dates from the time of Newton. Foucault, as early as 1855, demonstrated the rotation of the earth by means of the gyroscope and gave it its name. Since then the gyroscope has been applied in many ways—in fact, from a mere child's toy to a complicated and extremely accurate gyro-compass costing several thousands of dollars.

The interest of gyroscopes for us, apart from these recent applications, is also manifold. We live in a universe of gyroscopes; everywhere there is rotary motion. The earth is a gyroscope. We ride on gyroscopes, whether they be carriages, automobiles, trains, or airplanes. Our factories are full of gyroscopes, where occasionally ignorance of gyroscopic action and laws leads to death and disaster.

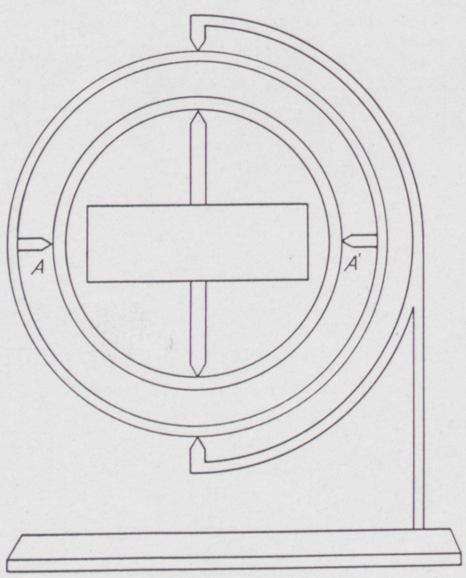

FIG. I

For example, the axle of a rapidly rotating grindstone works loose, and the stone flies apart, killing a workman. The cause is ascribed to simple centrifugal force or some other theory, but the stone would have withstood this stress if the same plane of rotation had been preserved. It could not, however, withstand the enormous gyroscopic couple, acting at right angles to its plane of rotation, when the axle moved.

This paper will therefore be devoted to a discussion of the fundamental gyroscopic principles.

The Gyroscope

The gyroscope is a mass universally mounted, i.e., mounted in such a way that it is free to rotate about any axis. This definition is within the scientific meaning of the term, yet it includes all rotating objects, differing only in their degrees of freedom. It may be easily understood, therefore, that all rotating masses are gyroscopes to varying degrees and that all possess gyroscopic characteristics in direct proportion to the magnitude of these degrees of freedom.

Gyroscopic phenomena are exhibited by all rotating bodies, but are more evident in those possessing high angular momentum. This momentum is dependent on the moment of inertia of the mass (the summation of the products of the individual masses and the square of the distances the respective masses are situated from the axis of rotation) and the speed of rotation. The angular momentum is evaluated by the formula,

$$M = w(\Sigma m^2 r)$$

where,

w=speed of rotation in radians per second.

m=individual particles of mass in poundals.

r=radius of rotation in feet.

It is obvious, upon inspection of this formula, that, for the gyroscopic action to be pronounced, the rotating mass must be heavy, the material should be disposed as far as practicable from the axis of rotation, and the speed of rotation should be as high as possible. These are the primary requisites of the gyroscope if the mechanism is to be used as such.

The Elementary Gyroscope

The ways in which gyroscopes are mounted are many and depend upon the duties they are to perform. For general study and discussion, the simple elementary gyroscope illustrated in figure 1 is best suited.

For simplicity of the figure, the gyroscope is shown with its spinning axis vertical. In the following discussion the instrument is treated as if the wheel, its axle, and the inside ring were turned ninety degrees about bearings A and A′ so that the spinning axis of the wheel is perpendicular to the plane of the paper.

This elementary gyroscope is supported at its centroid by means of nearly frictionless gimbals. This type of support is often called a *Cardan* suspension and allows the gyroscope wheel to spin with its axis in any direction, i.e., to have three degrees of freedom. These degrees of freedom of the elementary gyroscope are the following: (1) The wheel is free to rotate or spin about its "spinning" axis, the wheel's axle. (2) The wheel, with its axle and axle bearings, is free to rotate about the "horizontal" axis, which is in the plane of the wheel and intersects the spinning axis at right angles. (3) The wheel, with its axle, axle bearings, horizontal axis, and horizontal axis bearings, is free to rotate about the "vertical" axis, which intersects the horizontal axis at right angles at its intersection with the spinning axis. Thus it may be seen that, while the spinning and the horizontal axes are always perpendicular to each other and while the horizontal and the vertical axes are also always perpendicular to each other, the spinning axis may make any angle with the vertical axis. The spinning axis may also be in any direction horizontally, and therefore in any direction relative to space.

The Property of Rigidity In Space

The known gyroscopic phenomena and their various applications are all dependent on only two properties of the elementary gyroscope. These are: (1) rigidity in space, and (2) precession.

The first property is actually gyroscopic inertia and is in absolute harmony with Newton's First Law of Motion, which states: "Every body continues in its state of rest or uniform motion in a straight line unless it be compelled by impressed force to change that state." This law, as applied to a gyroscope, may be expressed by stating that the rotating wheel tends to maintain the absolute directions of its plane of rotation and its axis in space. This absolute direction is not relative to the earth, but relative to the universe.

This rigidity relative to space can be proved mathematically, but such proof is the work of a near genius and is beyond the scope of this paper. A simple experiment and consideration will illustrate well this property.

If the wheel of the elementary gyroscope already described is made to spin in any direction, it will be found to have assumed a rigidity of absolute direction of its axle and plane of rotation relative to space. It can be carried about on its support and have its base turned in any direction. The wheel and axle will make exactly the opposite motion by means of the freedom of the *Cardan* mounting, preserving the absolute direction of its axis relative to space. Now, if this gyroscope is considered to be made so that it can spin continuously and to be sufficiently frictionless in its supports, it can easily demonstrate the property known as "rigidity in space". If such a gyroscope is set at the earth's equator with its spinning axis horizontal in an east and west direction and is spinning continuously, the wheel will also apparently rotate about a horizontal axis which is at right angles to the spinning axis. This apparent rotation will proceed at the rate of one revolution per day. Actually, however, the gyrospinning axis has remained parallel with its original position in space, and the earth has made one revolution about its own polar axis. Figure 2 is a diagrammatic sketch of the positions of the gyroscope axis as the day progressed. At the end of three hours the west end of the axle as viewed looking north was depressed 45 degrees with the horizontal. At the end of six hours the gyroscope axis was perpendicular with the earth's surface, having been carried through one-quarter of an apparent revolution in one-quarter of a day. At the end of twelve hours it was again horizontal but with its ends reversed, as viewed by the observer looking north; but actually the gyroscope axle was still parallel to its original position in space and pointed in its original direction in space. At the end of one complete revolution of the earth the original position of the gyroscope axle was apparently regained.

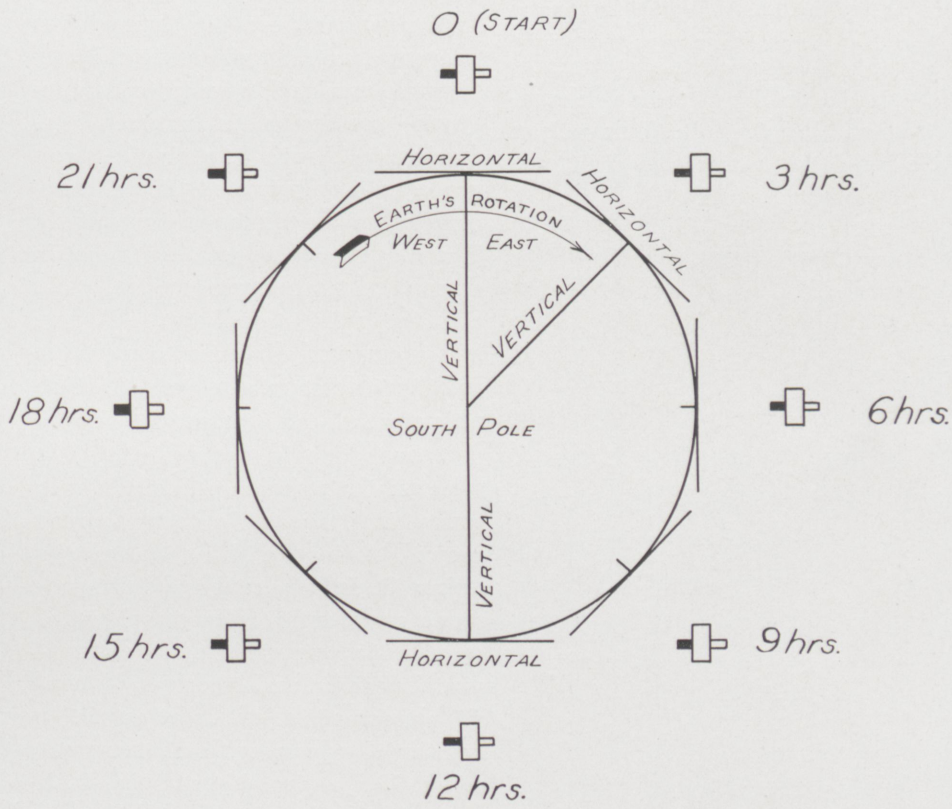

FIG. 2

Similarly, if the same gyroscope were placed at the North or the South Pole, it will also have an apparent rotation. By following the same line of thought, it will be concluded that the apparent rotation will be about a vertical axis, as compared with apparent rotation about a horizontal axis at the equator. Still further reasoning will lead one to the conclusion that the axle of such a gyroscope placed at some intermediate latitude, with the gyroscope horizontal and in the meridian, will have an apparent rotation neither parallel to nor perpendicular to the earth's axis, but at an angle to it equal to the latitude.

These experiments and considerations, as previously stated, are shining examples of Newton's First Law of Motion. Although this rigidity in space is one of the fundamental principles of the gyroscope, it is not inherently a gyroscopic property. Any balanced mass at rest with a corresponding freedom to move would show a similar phenomenon if there were no friction. It is only that, in the case of the gyroscope, friction is reduced to an almost negligible amount in comparison with the forces necessary to disturb the plane of rotation.

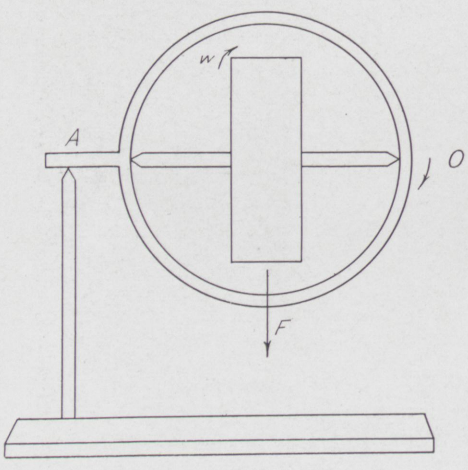

FIG. 3

The Property of Precession

The property of the gyroscope known as precession is displayed when a force is applied to the gyroscope tending to change the plane of rotation of the spinning wheel. Precession may be defined as follows: When a gyroscope is subjected to a force which tends to alter the direction of its axle in space, the force meets with great resistance, and the gyroscope wheel will turn about an axis at right angles to the axis about which the force was applied. This movement tends to place the plane and direction of spinning rotation of the wheel coincident with the plane and direction of the force by the shortest method.

It is not to be understood by this definition, however, that the gyroscope will maintain its plane of rotation. A gyroscope spinning with infinite velocity—a mathematical fiction—cannot have its plane changed by any finite force. In this case, it is a gyrostat, but finitely spinning gyroscopes do not and can not maintain their planes when acted upon by an outside couple.

This property of precession may be illustrated experimentally in the following manner: No force is so universal as that of gravity; therefore the use of this force to demonstrate precession is natural. Referring to Figure 3, a simple gyroscope with only two degrees of freedom is supended on the pivot A. The angular speed of the wheel is designated by the arrow w. Naturally the gravitational force, F, acts in a downward direction, causing an unbalanced couple about A. The phenomenon of precession of the gyroscope lies in the fact that the effect of the unbalanced couple is to cause the axis of spin to sweep around A in the direction of the arrow O. In other words the gyroscope apparently defies the laws of gravitation by remaining in its horizontal position and has the additional phenomenon of rotation in a horizontal plane without apparent cause. If the direction of spin, w, is reversed, the gyroscope will turn in the opposite direction.

The torque causing precession, or gyroscopic moment as it is sometimes referred to, may be evaluated by the formula,

$$T = IwO$$

where,

I=moment of inertia of the rotating mass.

w=angular velocity of spin in radians per second.

O=angular velocity of precession in radians per second.

It is not to be concluded from this simple demonstration that the phenomenon of precession is by any means simple. For example, when the gyroscope wheel is spinning at the rate of 30,000 to 40,000 revolutions per minute, two forms of precession are in evidence: the ordinary slow precession and a fast minute precession which apparently takes place without the action of an outside couple and which is called the "adynamic" precession. The term "adynamic" does not mean that the gyroscope precesses without the action of a couple but merely that the gyroscope itself develops the necessary couple causing "adynamic" precession as the gyroscope precesses slowly.

Conclusion

Many other demonstrations and experiments illustrating in greater detail and complexity the two major gyroscopic principles are available, but they are beyond the scope of this paper. However, the elementary discussion which has appeared herein will serve as a basis for a practical comprehension of the gyroscope in its various applications.

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Commercial Preparation of Aluminum

by

Emil G. Christiansen, ch., '40

Since aluminum is destined to play such an important part in both the industrial world and everyday life, knowledge should be had of the colorful history of its development, the various methods by which it is produced, and its advantages and disadvantages in comparison with other common metals. Mr. Christiansen points out in an interesting manner the more important facts about aluminum.

ALUMINUM is a metallic element which is unknown in a natural free state, occurring principally in the form of silicates. It is the most abundant metal, comprising 7.85 per cent of the known terrestrial matter. The chief natural compounds of aluminum are four in number: Corundum, Al_2O_3, is found in southern India and in the United States. Since its composition is simple and it contains a greater amount (52.9 per cent) of aluminum than any other natural compound, it would seem that it would be popular as an ore in the production of aluminum. However, because of its extreme hardness, 9 on the Moh scale, and because of its value as an abrasive, it is not employed. Cryolite, $AlF_3{\cdot}5NaF$, is found principally

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Open Pit Mining of Bauxite, the Ore of Aluminum

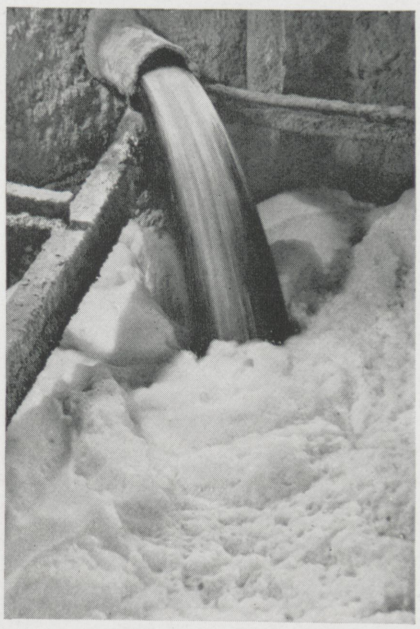
on the west coast of Greenland, with small deposits occurring in the United States and Russia. It is prepared artificially for use as an electrolyte in the production of aluminum. Kaolin, Al_2O_3-$2SiO_2$-2HOH, is the most widely distributed aluminum ore, being present throughout the world. However, at the present time, no commercially practicable method has been found for preparing pure aluminum from it. Bauxite, $Al_2O_3{\cdot}2HOH$, is found principally in southern France, northern Ireland, Alabama, Georgia, and Arkansas. It is the ore which is almost exclusively used for the production of aluminum.

History of Aluminum

Lavoisier predicted in 1782 that alumina, Al_2O_3, was the oxide of a metal not then known. In 1808 Sir Humphrey Davies attempted to decompose alumina by heating with potash in a platinum crucible and subjecting the mixture to an electric current. At the time he was unsuccessful. In 1809, however, with a more powerful battery he raised an iron wire to a red heat in contact with alumina, producing an iron-aluminum alloy. Davies named the new element aluminum, or aluminium as it is still called in Europe.

In 1824 Oersted heated aluminum chloride with potassium amalgam but failed to produce pure aluminum only because of the mercury present. A few years later Wohler, repeating Oersted's experiment of 1824, and using potassium alone as the reducing agent, succeeded in producing metallic aluminum. However, because of the potassium and the platinum from the crucible, it was far from pure.

In 1854 Deville, apparently in ignorance of Wohler's experiments, duplicated them. Noticing the reduction of the chloride, he realized the importance of the discovery and immediately began to study the possibilities of the commercial production of aluminum. His attention was divided between the reduction of the chloride with potassium and the electrolytic method of decomposition. However, both methods seemed impracticable. Potassium at that time cost $85 a pound, and besides the reaction was violent and



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A Step in the Chemical Treatment of Bauxite

dangerous. Also the only source of current available at that time was the primary battery. Accordingly he turned again to pure chemistry, inventing a practical method of producing sodium, which because of its lower atomic weight, reduced in larger proportions than potassium. He first used the chloride of aluminum, but because it was volatile and extremely deliquescent, he soon substituted a double salt of sodium and aluminum.

The Deville process, as elaborated between 1855 and 1859 consisted of three distinct phases: production of metallic sodium, formation of a pure double salt of sodium and aluminum, and the production of pure aluminum by the interaction of the two former substances. To prepare sodium, a calcined mixture of sodium carbonate, coal, and chalk was ignited in boiler plate retorts, and

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Pouring Aluminum Pigs in a Reduction Plant

the sodium distilled over into condensers. In order to prepare the double salt, the oxide, alumina, was first prepared by heating bauxite and sodium carbonate until the reaction was complete. The product was then extracted with water, the solution treated with carbon dioxide, and the precipitate removed and dried. The purified alumina, mixed with sodium chloride and coal tar was carbonized at a red heat, and ignited in a current of dry chlorine. The vapors of the double chloride were then condensed. For the preparation of aluminum, about a hundred parts of the chloride, powdered together with forty-five parts of cryolite to serve as a flux, were mixed with thirty-five parts of sodium cut into small pieces. The mixture was thrown in small portions into a furnace which had been heated to a dull red heat and stirred at intervals for three hours. When the furnace was tapped, a white slag was drawn off the top, and the liquid metal beneath was drawn off into cast iron molds. Deville's method, with certain modifications, dominated the field for approximately thirty years until 1891, when the electricians commenced to offer aluminum at a much cheaper price. Hall and Heroult in 1886-7 had almost simultaneously discovered the electrolytic method, and the Deville method was then a thing of the past.

Modern Production

One of the most radically different features of modern aluminum production, as compared with that of other metals, lies in the preliminary treatment of the raw materials. There are two principal stages in the present method of production. The first is the preparation of pure alumina, Al_2O_3, from some aluminous mineral, usually bauxite. The second is the reduction of this pure alumina to aluminum in a bath of fused cryolite. The reason for these two separate stages is that impurities in the raw materials must be removed before aluminum is actually produced. It has proved practicable first to prepare pure alumina and then the pure metal, rather than refine an impure metal which would be produced by the direct electrolyzation of the raw material. Bauxite is the mineral almost exclusively used, and most of it is worked by the Bayer process. There is a tendency to employ other and cheaper methods, using different and cheaper ores, but their use has not yet become widespread. In all there are twelve processes which are in use or are reasonably practical for the production of alumina of high purity from aluminous ores. The four principal processes which will be discussed are the Bayer, Hall, Pederson, and Haglund processes.

Bayer Process

This process requires a high grade of bauxite, the following table giving the limits of impurities allowed for the ore used in this process:

Al_2O_3	55-60%
Fe_2O_3	20-25%
TiO_2	2- 3%
SiO_2	1- 3%
H_2O and organic impurities	12-15%

The ore is crushed and ground to a 70 mesh fineness. It is then mixed with strong soda liquor and digested in a steam-jacketed autoclave for 8 hours with steam at 50 pounds pressure. This treatment dissolves the Al_2O_3. This mixture is blown into tanks and diluted to a density of 1.20. It is then filterpressed, the impurities, Fe_2O_3 and TiO_2, remaining in the residue. Pure alumina is then precipitated from the filtrate by slow agitation and the addition of a small amount of aluminum hydroxide. The precipitate is then filtered off, washed, dried, and calcined to alumina at 1,100° C. in a rotary kiln.

The Bayer process is the one employed to the greatest extent. However, it is imperative that an ore of high grade be used. A silica content of over 3% in the ore prohibits its use in this process.

Hall Process

In the Hall process a bauxite of lower grade than that required for the Bayer process may be used. In fact, this process is one of the most important methods of treating lower grades of bauxite ore.

Low grade bauxite is ground to granular form and mixed in a variable proportion, depending on its composition, with ground coal. The mixture is sintered at 1000° C. and cooled, and more coke is added to reduce the impurities. The mix is then smelted in an electric furnace, using electrodes of the Soderberg type, at 2500° C. FeSi and FeTi sink to the bottom. The pure alumina is blown off by steam or air pressure into iron-lined chambers. After it has cooled, it is leached with hot water and dilute sulphuric acid to dissolve any TiO_2. The solid alumina remaining is filtered off and dried. The alumina produced by this process is in the form of solid bubbles and is lighter than that produced by the Bayer process.

Pederson Process

This process is especially suited for the production of alumina from low grade bauxite ores having a high iron content. The charge consists of a mixture of iron ore, limestone, and bauxite. This charge is placed in an electric smelting furnace, and the iron impurities in the bauxite smelted out. This iron, along with the iron obtained from the iron ore, is tapped off and cast into pigs. The rich aluminous slag is tapped off, cooled and crushed. It is then leached with hot dilute sodium carbonate solution. The alumina which precipitates out is filtered, washed, and dried.

Haglund Process

This process is used to some extent in Europe and is well-suited for low grade ores.

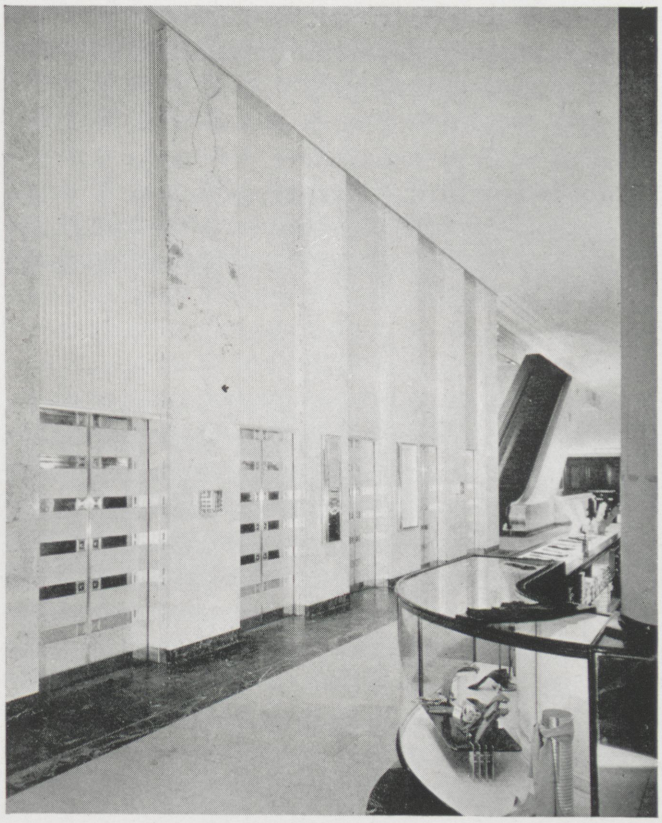
The low grade bauxite is crushed and mixed with the correct proportions of anthracite coal and occasionally pyrites. This mixture is fused in a resistance furnace. The richly aluminous slag floats to the top and is tapped off and cooled. At this time some of the aluminum crystallizes out as alumina. The mixed slag is crushed and leached with water and steam, converting the aluminum sulfide to insoluble aluminum hydroxide. After leaching, the residue contains not only aluminum hydroxide, but also mixed oxides and sulfides of other impurities. The mixture is treated by classification and concentration. Aluminum hydroxide with a certain percentage of alumina is removed. The alumina is washed and dried, and the aluminum hydroxide is dried and calcined to alumina.

Details of Hall Process

Hall in America and Heroult in France both conceived the idea of producing aluminum from pure alumina by dissolving alumina in fused cryolite and passing an electric current through it. The methods are almost identically the same, the Hall process being used in America and the Heroult in Europe.

The furnace in which the aluminum is produced is commonly called the "pot" and is a rectangular steel shell, lined with baked carbon. The lining is composed of a mixture of ground coke, tar, and pitch and is rammed and baked in place. The coke used is usually a high-grade furnace or foundry coke. The ash content must be as low as possible, since any impurities which are present will find their way into the aluminum. The coke, when it is received at the plant, is ground, dried, reground, screened, and then stored. The pitch, which is usually received in lumps, is also ground. To make the lining, pitch and tar are mixed with coke to make a mix of the required plasticity. This is then blended in a steam-jacketed autoclave. When the plastic mass has become thoroughly blended, a certain amount is poured into the shell and rammed in place. A cast iron shell is then centered in the pot as a core, and more of the mix is tamped around it until the space between the shell and core is filled. The pot, with the core still in place, is then run into a baking furnace. When the lining has been thoroughly baked, the pot is run out of the furnace, and the core removed.

In the manufacture of the carbon anodes, the major material used is petroleum coke, since it is ash free. The coke is crushed, screened, and certain definite amounts of both large and small lumps are then remixed, so that the charge to the calcining furnaces will always contain the same proportions of the large and small lumps. This is necessary for uniform and efficient operation of the calcining furnaces. The calcined coke is then ground, screened, and stored. The second major material used in the electrodes is pitch. This is merely ground and stored. The other two raw materials used are reclaimed electrodes and "green scrap"; that is, electrodes which have never been used because of some imperfection. Although the electrodes are almost completely used up in the operation of the pots, it is still profitable to reclaim that part of them which has not been used. These two materials are also ground and stored in separate bins. The correct proportions of these four raw materials are weighed out and blended in a mixer identical to that used for the lining mixture. The properly blended mixture is then conveyed to the press hoppers where it is molded into shape. The green electrodes which discharge from the press are placed in steel baskets and baked in a packing of finely ground petroleum coke. This is done by passing a heavy electric current through the electrode mass, which itself acts as a resistor and heating unit. When the baking process is finished and the electrodes have



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Aluminum as Used in the Marshall-Field Store, Chicago

cooled, they are fitted with metal conductors.

In a typical operating setup of this process, about 100 furnaces are connected in series so that there are only about six volts across each one. However, heavy currents, from 8,000 to 20,000 amperes, are used. The furnaces are run at a temperature of 950° C, which is produced by the passage of the current and which fuses the cryolite. This temperature is above the melting point of aluminum (660° C), and since the density of aluminum is greater than that of cryolite, it sinks to the bottom in the molten state. Pure alumina is dissolved in the fused cryolite. It is possible to dissolve 20% of alumina in cryolite, but this is never attained, for the rate of solution of alumina in cryolite is very slow, and there is danger of the alumina settling on the bottom. In practice, the maximum concentration of the alumina in the cryolite must be kept low. While the furnace is operating, there are four distinct layers of material in it. On the bottom is the layer of molten aluminum. On top of that there is the bath of fused cryolite. Above the fused cryolite there is a thin layer of solid frozen cryolite. A layer of alumina is spread on top of this so that it may be warmed.

As the electrolysis proceeds, the concentration of the alumina naturally decreases, until it reaches a point at which the so-called "anode effect" takes place. The conditions which produce this effect are not always constant, hence it does not occur at any definite, constant concentration of the alumina in cryolite. However, the results are always the same; the resistance of the furnace rises sharply, and the voltage jumps to several times its normal value. The electrolyte no longer "wets" the electrodes, and they seem to be surrounded by a gaseous film through which an arcing of the current takes place. It is, of course, desirable that the duration of this effect be kept at a minimum. When this effect is noticed, the operator breaks through the crust of frozen cryolite and stirs into the bath some of the alumina which has been warming on top, until the concentration goes up enough to stop the effect. He must be careful, however, not to stir in too much alumina, or it will not all dissolve. It is evident then, that in an efficiently operated furnace this anode effect will occur at fairly regular intervals but that its duration is kept to a minimum.

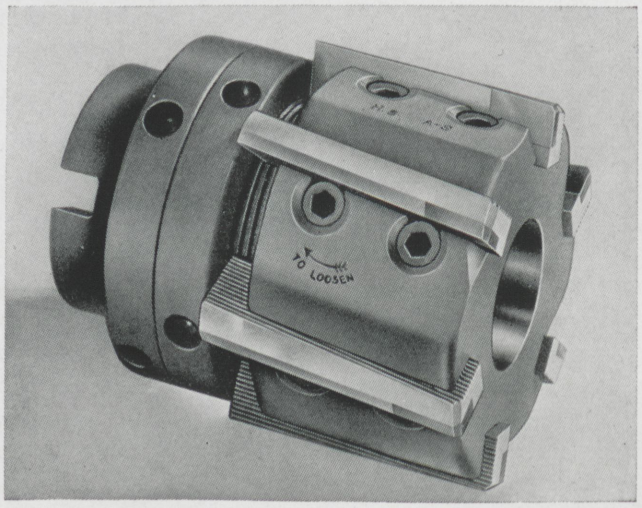
The furnaces are tapped every one, two, or three days by special crews. This is done simply by driving a steel pin into the furnace through the tap hole and allowing the molten aluminum to flow into ingot molds. It is usually cast in 50 pound ingots.

Theoretically, the reaction for the production of aluminum requires 2/3 pound of carbon per pound of aluminum produced. In practice, however, the electrode consumption is about ¾ pound per pound of aluminum, and some plants work on a pound per pound basis; that is, one pound of carbon per pound of aluminum produced.

The theoretical power consumption for this reaction is about 5 k.w.h. per pound of aluminum. Since a large amount of power is consumed in the heating of the pots, the actual power consumption is 12.5 to 13 k.w.h. per pound of aluminum produced.

Conclusion

The importance of aluminum is unchallenged; its uses are too numerous to mention. The metal produces an enormous number of useful and important alloys. It plays an important role in the purification of iron and steel. Although this was once the most important use of aluminum and employed a greater percentage of all the aluminum produced than any other of its applications, this remarkable metal soon became important in many diversified fields. To the general public it appeals most strongly as a material for constructing cooking utensils. It is not brittle like porcelain and cast iron, not poisonous like lead-glazed earthenware and untinned copper, needs no enamel that might chip off, does not rust or wear out, and weighs but a fraction of other substances. It is largely replacing brass and copper in all departments of industry—especially where dead weight must be moved about and lightness is synonymous with economy. With the decreasing price of aluminum, it is coming into vogue as an electrical conductor, for uncovered mains. Much has yet to be learned about the practical qualities of this electrolytic product, and every day's experience serves to place the metal in a firmer industrial position.



Use of Aluminum in Machine Shop Tools

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THE ROSE TECHNIC

Member Engineering College Magazines Associated

An Engineer At His Best

The engineering profession is constantly having the shortcomings of some of its members thrown in its face. The most talked of engineer of the day is, however, one of whom the profession may well be proud. That engineer is Dr. Arthur E. Morgan, chairman of the TVA. Aside from his technical ability Dr. Morgan has exhibited an almost unprecedented degree of integrity, moral courage, and sense of responsibility concerning his job.

When Dr. Morgan was appointed to the important position which he now holds, he accepted the appointment as any engineering task and has subsequently treated it as such. His job, as he saw it, was to complete as efficiently as possible the assignment before him. Any program which demands efficiency cannot tolerate graft and corruption. Dr. Morgan's associates did not recognize this fact, and consequently a most embarrassing situation has arisen. Dr. Morgan, not unaware of what was happening, preferred charges against his two associates, not because he could hope to gain thereby, but because it was his moral obligation as an ethical engineer.

Chairman Morgan did not, however, contemplate a hostile president—an administration that would try to conceal what appears to be the biggest scandal of its type since the Teapot Dome. Not to be taken back, Morgan has demanded, and rightfully so, a Congressional investigation. When this demand was made, an immediate presidential ultimatum was issued ordering him to either drop his charges or resign. He did neither. Instead Dr. Morgan retained the courage of his convictions and refused to retreat pending the investigation, regardless of the threat of removal. Thus, no matter what the outcome, we have seen a morally upright man—an engineer at his best.

R. S. K.

Instrumentalities of Engineering

The instrumentalities which an engineer must utilize are method, materials, money, and men. In determining the method or materials to be used, use is made of the exact sciences. In dealing with problems regarding money and men, judgment and past experience must be resorted to.

Method involves largely the science of engineering, such as calculating the magnitude of forces, pressures, power yield, water yield of a stream, and the capacities of machines.

Materials include a knowledge not only of the primary materials, such as iron, steel, aluminum, copper, timber, and stone, but of the derivatives obtained from them. The properties of these materials, such as strength, hardness, elasticity, flexibility, and durability, must be known quantitatively. It is thus seen that the study of materials is an important factor.

Money is the fundamental of practically all engineering work. The first question is always whether to undertake a project or not, and the answer to that question will usually depend on whether it is economically feasible. As one prominent engineer puts it, "Whatever may be the numerator of an engineer's fraction, dollars will always be the denominator".

Men constitute the fourth instrumentality that an engineer must be able to use intelligently if he is to enjoy success. Besides having to direct large forces of workmen, the engineer must be able to work harmoniously with colleagues and superiors in an organization.

W. A. R.

Reading

Many of us recall in the secondary schools that it was necessary to do some outside reading. This should have resulted in the formation of the habit of doing some reading every day. By reading some worthwhile article in a good newspaper on some current event or proceeding, one is able to talk intelligently to others about matters of mutual interest and also to acquire knowledge for himself.

The sources of material are abundant and available here at school. The library has many daily newspapers and periodicals of interest. Such reading is for pleasure and personal information and not necessarily for study. Several books not pertaining directly to courses of study also represent an excellent investment of leisure time. Reading under these conditions is time well spent and, if the fullest benefits are derived, is both interesting and enjoyable.

N. G. W.


ROSE POLYTECHNIC INSTITUTE
LABOR ET SCIENTIA
1874

Campus Activities

edited by
J. Edward Taylor,
ch., '40

Engineering Alumni

The March issue of the publication, *Mechanical Engineering,* sponsored by the American Society of Mechanical Engineers, included an article, "Alumni of the Engineering Colleges," by President Donald B. Prentice.

Dr. Prentice's contribution represents a brief summary of the returns of the 176,000 questionaires which were mailed to the engineers whose names appeared in the recent United States Department of Labor census and incorporated by the American Engineering Council to form the latest edition of "Who's Who in Engineering," a volume containing 12,000 biographies. Nine thousand eight hundred forty-five of these biographies belong to college men who are graduates from 307 colleges in the United States and Canada.

In the comparison of the numbers of graduates of the various institutions who were included in the volume, the Massachusetts Institute of Technology headed the list with 761 graduates. In the table of geographical distribution of colleges having the greatest number of alumni listed, New York state recorded 1,439 inclusions from fourteen colleges. The data on living alumni of the twelve leading engineering educational institutions of similar type reveal the Michigan College of Mining and Technology in first position with 6.13 per cent of its graduates in "Who's Who in Engineering." Rose Polytechnic Institute is third by virtue of 4.61 per cent of its graduates obtaining this recognition.

Assembly

The Rose Show committee called an assembly on Thursday morning, March 17, to report to the student body that the preliminary arrangements have been virtually completed.

General Chairman J. Allen Greenland first called on Professor Clarence Knipmeyer, faculty chairman, who repeated his statement at an earlier meeting concerning the willingness of the faculty to co-operate with the students in working out their ideas. The success of the show is near to the heart of Professor Knipmeyer since he played a large part in establishing the custom at Rose twelve years ago, and he took pleasure in stating that progress on the coming exhibition is considerably in advance of previous schedules.

Coach Phil Brown, public relations councilor, was well received in his request that he be given detailed descriptions of the different projects.

Then the class committeemen from each department announced, without exception, the high order of enthusiasm with which the men in his department were assailing their problems.

After displaying the item which has been selected as this year's souvenir, a useful ash-tray done in unburnable lacquer, Chairman Greenland closed the meeting with the veiled hint that less time could be devoted to the pursuit of academic and *extra-curricular* accomplishments, temporarily.

The show must go on.

Birth of an Organization

A recent innovation to the campus is the establishment of a club whose official name is the "R" Men's Association. Its avowed purpose is to enhance the value of athletic activities to the student body and to promote a closer relationship between the non-participating student and the inter-collegiate competitions.

Prospective members must have earned a letter and sweater in football, basketball, or rifle team work. Managers of the respective sports are also eligible to join the organization, and all alumni letter men will receive personal invitations to take membership. Advance information may be obtained from Coach Phil Brown.

On Saturday evening, March 19, the club held its inaugural meeting at Antoninni's Italian Cafe in Clinton. After dinner Coach Brown outlined the immediate needs of the foundling. Officers who were elected for the next year are: Robert McKee, president; George Smith, vice-president, and Robert Underwood, secretary-treasurer. All alumni letter men are invited to attend the next dinner meeting.

A. I. Ch. E.

The first anniversary of the installation of the student chapter of the A.I.Ch.E. at Rose was observed by the chapter with a dinner meeting on Wednesday, March 9, in Deming Hall.

Retiring President Norman G. Wittenbrock opened the meeting with a short summary in which he described the eventful course of the year's activity. He paid particular tribute to Dr. John White and Dr. James Withrow, Founders' Day speakers, and to Dr. Jules Bebie, Captain Frederic Henney, and Mr. George Armstrong, who all contributed to the year's program.

Sergeant-at-Arms William Serban then conducted Edward Taylor, Richard Altekruse, and Ewing Ross into the offices surrendered by Robert Kahn, secretary-treasurer, William Wolf, vice-president, and Norman Wittenbrock, president, respectively. Following the presentation of the charter President Ross named standing committees for the year: Robert Burger and Walter Zehnder, programs; and Luther Yaeger, William Julbert, and Edwin Barrick, professional development.

The chapter was honored by the presence of Mr. F. B. Langreck, assistant vice-president of the Monsanto Chemical Company of St. Louis; Dr. D. B. Prentice; Mr. H. L. Comin, of the Terre Haute Gas and Coke Company; Mr. C. W. Fredrichs, of the Merchants Distilling Corporation; and Mr. Robert Failing, alumnus of the class of 1922. Mr. Comin was voted an honorary membership in recognition of his active interest in the chapter.

Dr. R. K. Strong, chapter adviser, introduced the principal speaker by describing the underlying reason for the good fortune of the group in being permitted to command his services. Mr. Langreck gave an informal address on "What Industry Expects of the Chemical Engineering Graduate." His talk was a masterpiece of conciseness and clarity. He explained to those who were privileged to hear him that native intelligence, a sense of responsibility, the ability to reason and foresee, and the ability to cooperate with other people were cardinal virtues greatly desired by the business world.

Glee Club Concert

The Rose Glee Club made its first presentation of the season on Tuesday morning, March 15, with a concert given at Glenn High School.

The morning's program directed by Mr. Chelsea Stockwell consisted of:

"Dear Old Rose".......... (theme song)
"Off to the Southward"
.... (seaman's chanty)
"Pop Goes the Weasel"........Schaffer
"Sea Fever"................Mark Andrews
"Heart of You"............Dvorak-Parks
"Hoodah Day" .... (chanty)
"Battle of Jericho" (negro spiritual)
Czechoslovakian dance ......Smetana
"Drums" ....DeLeane
"What Shall We Do With the Drunken Sailor?".... (traditional chanty)

Mrs. Edris Bennett continues to serve as accompanist to the club. The members are: Wendell Carroll, John Hayes, George Neyhouse, Stanley Craig, Logan Davis, Franklin Doenges, James Ducey, Maurice Fleming, Robert King, Vernon Whitehouse, Adrian MacFarland, Edward Taylor, Joseph Robinson, Richard Mullins, Mark Anthony, Milton Hosack, Frank Beeler, John Carroll, Hugh Chapman, Joseph Dreher, Carl Hessler, Raymond Hogan, Roger Howle, Robert Phelps, David Roach, and Robert Gerow.

Rose Rifle Club

The Rose Rifle club, having offered appropriate insignia to be awarded to members of the R.O.T.C. Rifle Team who placed in stages of the Fifth Corp Area Inter-collegiate Rifle Match, 1938, has authorized the following to wear the same: Edward Eckerman (with 3 stars), Victor Peterson (2 stars), Maurice Fleming, William Wolf, Walter Zehnder, Robert Underwood, (one star each), and John Whitesell. Chancellor Montgomery, Stanley Craig, John Kowinski, Ernest Palisin, Paul Bell, Charles Howlett, Somers Blackman, and Thomas Lane.

"Sarge" Kearns, coach, came upon an unusual circumstance when the season's scores were summed. Ed Eckerman led Moritzy Fleming by only one point, the closet race for the marksman's championship in the history of the club.

Rifle Club Scores

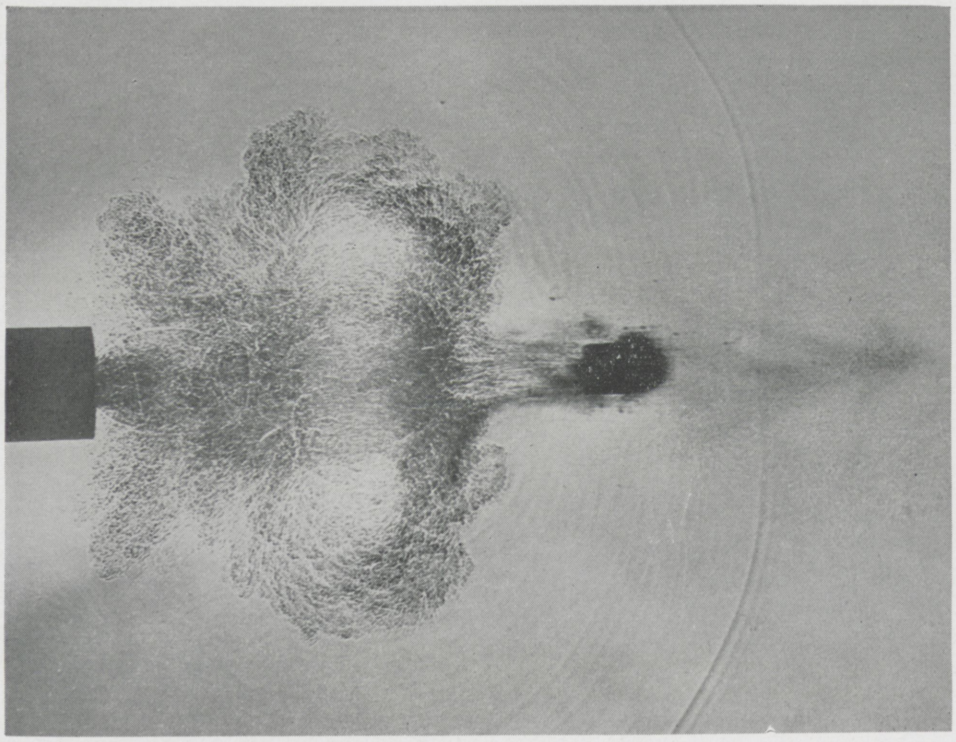
1. University of California at Berkeley 3740
2. University of Missouri...3710
3. Culver Military Academy 3683
4. Agricultural and Mechanical College of Texas.....3638
5. University of Alabama...3596
6. Rose Polytechnic Institute 3519

This match was held between the varsity teams of the various schools and the competition included all positions.

Research and Progress

edited by

L. J. Giacoletto, e., '38



Cut Courtesy Mechanical Engineering

Fig. 1. Projectile in Flight

Seeing High Speed Objects

Only in recent years have methods been devised for photographing objects traveling at high velocities. A summary of the development of this type of photography, written by R. Merwin Horn, is contained in the March, 1938, issue of *Mechanical Engineering*. High-speed photography has been developed largely through the efforts of Prof. Harold E. Edgerton and his associates, B. J. Germeshausen and H. E. Grier of the Massachusetts Institute of Technology. The two prime requirements of high-speed photography are a controlled source of brilliant illumination and a suitable high-speed camera. For illumination a spark discharge either through air or a gaseous tube, such as mercury or argon, is employed. This type of illumination gives a flash of light lasting 0.00001 second. If only one view of the moving object is desired, suitable control must be exercised so as to flash the light at the desired moment. However, if a series of pictures is desired, the light must be flashed on and off several thousand times a second to correspond with the individual pictures. A commutator on the main drive shaft of the camera is used to provide the necessary switching. The camera and commutator are shown in figure 2. The camera has no shutter mechanism but depends solely on the intermittent light for shutter action and object illumination. The contacts are so placed on the commutator that the film moves the distance of one standard motion-picture frame for each flash of light.

High-speed photography has found a wide range of applications. It has been used to make precise measurements of bullet velocities in the study of ballistics, to investigate vibrations in high speed machinery, and to study airplane propellors while in operation. The high-speed camera has even been used in medicine to study the action of high-speed micro-organisms.

The Profilometer

Modern high speed applications require working surfaces of great accuracy and smoothness. The necessary requirements of an instrument for measuring surfaces are that it must possess speed, sensitivity, range, accuracy, flexibility, and adaptability. The profilometer, perfected by the Physicists Research Company of Ann Arbor, Michigan, suitably fulfills these requirements.

The constituent parts of the profilometer are a tracer to detect the irregularities in the surface, an amplifier to magnify them, and a recorder to record the type and magnitude of the iregularity. The tracer consists of a tracer point which is a small diamond held in contact with the specimen by delicate spring tension. The tracer point can move freely in a direction perpendicular to the surface, but its movement is restrained in other directions. Mounted on the tracer point is a small coil located in the field of a permanent magnet. Movements of the tracer point cause electrical voltages which are proportional to the velocity of displacement to be generated. These small voltages are then amplified with vacuum tube amplifiers and recorded. For recording, a cathode-ray tube is used to visualize the irregularities, and a moving film is used to make permanent recordings of the oscillograms.

The profilometer is remarkably sensitive, measuring irregularities of a few microinches. Magnification is sufficient to make these small irregularities visible. The amount of magnification is also conveniently controlled by merely adjusting the gain of the amplifier. Thus magnification from 1000X to 50,000X can be obtained with equal facility. At 50,000X, a microinch is nearly 1/16 inch and a human hair would have the appearance of a log 15 feet in diameter.

Special circuits in the profilometer can be used to separate the various types of irregularities. Profiles of the surface showing first both waviness and roughness and then only waviness can be obtained.

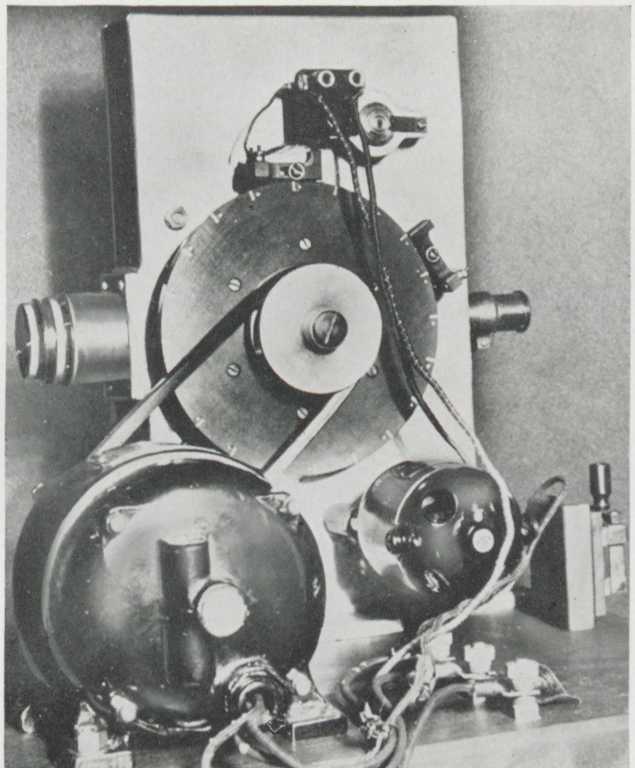
In some uses of the profilometer, an actual view of the profile is not desired but a rating of the surface is required. This can be accomplished by attaching a voltmeter to the output of the amplifier. The meter records the root-mean-square value of the irregularities. The presence of isolated scratches is clearly indicated by sudden jumps of the meter.

Hearing Impairment and Sound Intensity

The usual method of making measurements of hearing impairments is on the basis of the threshhold of hearing; that is on the minimum audible sound in quiet surroundings. Average threshold intensities have been established for people of normal hearing ability. For measurement, the ratio between the normal and observed intensity is taken as the degree of hearing-impairment. Recently research men at the Bell Telephone Laboratories have made hearing-impairment measurements at sound intensities above threshold. In these tests, a person with one normal and one impaired ear was asked to balance the tone heard with the normal ear against the same tone heard with the impaired ear. From tests on several subjects, it is evident that in some cases the hearing loss is constant and independent of intensity, however, in other cases, the hearing loss became less as the level was raised. Other tests were also made to show that loss caused by noises masking a given sound was of the variable type; that is, the loss was dependent on the intensities.

Cut Courtesy Bell Laboratories Record

Making Hearing Impairment Tests.



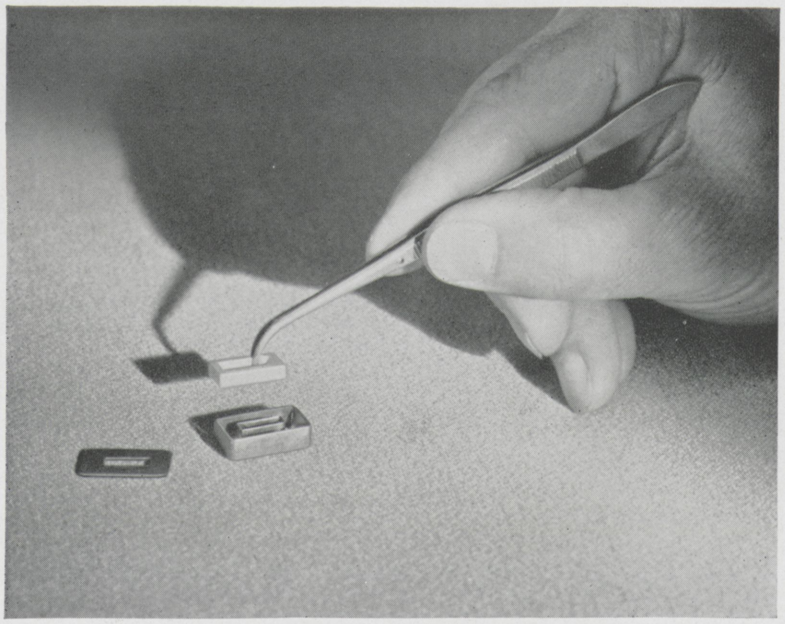
Cut Courtesy Mechanical Engineering

Fig. 2. High Speed Camera.

Higher Magnetic Permeabilities

About twenty years ago, it was discovered that certain alloys of iron and nickel have remarkable magnetic properties, one of which was high magnetic permeability or susceptance to easy magnetization. These alloys were named permalloys. Recent investigations of a permalloy containing 66 percent nickel has resulted in even higher permeabilities than have ever been obtained.

Experiments carried on several years ago at the Bell Telephone Laboratories resulted in the heat treatment of the permalloy in a magnetic field after it had first been purified in hydrogen at a high temperature. The permeability in this case was increased to 500,000. Further developments led to the preparation of single crystals, and measurements were made on the crystal to determine along which axis it could be magnetized most easily. These investigations resulted in the cutting of the specimen with sides parallel to the crystal axes. The specimen after being etched lightly with acid to remove surface strains caused by cutting was annealed in an atmosphere of pure hydrogen for eighteen hours at 1300 degrees Centigrade. A wire was then wound around the specimen so that a magnetic field could be produced in the desired direction. The specimen was maintained at 500 degrees Centigrade while being subjected to a magnetizing force of ten oersteds. The specimen was then cooled. After



Cut Courtesy Bell Laboratories Record

Specimen of highly-magnetized material.

repeated treatments a specimen such as is shown in the figure was obtained. Measurements on this specimen gave a maximum permeability of 1,330,000. For such a specimen, a magnetizing force equal to one percent of that of the earth will cause a flux through the crystal's four square millimeters about equal to that through a square foot of the magnetic field of the earth.

The experiments have served to confirm principles which were arrived at by other studies. The factors which were found to favor ease of magnetization were (1) absence of strains associated with hardworking, dissolved impurities, and grain boundaries; (2) choice of a proper crystallographic direction for magnetization; (3) presence of a magnetic field in the direction chosen (4) appropriate composition for the application of the magnetic field. As a direct result of the discoveries on crystal orientation, transformer sheets are now being rolled by some concerns so that the crystallographic direction of easiest magnetization are aligned in desired direction with respect to the dimensions of the sheet.

A continuing program of research in the development of new magnetic materials has already resulted in entirely new designs for many devices. These new findings give promise of even more revolutionary changes.

Sports

edited by
Robert N. Ladson, ch., '39

On February 29, 1938, the Rose Poly Engineers made a trip to Hillsdale, Michigan, for the final game of the season. This trip was previously planned to include three games: the Hillsdale game, Detroit Tech, and one with a team which had not been decided upon. However, just one week before the trip began Detroit Tech cancelled their game, so no attempt was made to secure the third game. As a finale to the season, Hillsdale won the game 42-24.

The game began very fast as far as the players were concerned, but the scoring did not proceed very rapidly. Hillsdale had built up a defense for Colwell, who last year defeated them almost single-handed, and he was not allowed to collect many points. The score at the half stood 14-10 in favor of Hillsdale.

In the second period the Hillsdale team came back with everything in the books and made up several things on their own hook. Time after time they came crashing down the the floor to fling the ball at the basket, and luck certainly appeared to be on their side. It seemed that the only necessity was to throw the ball at the back board, and two points were marked up on the scoreboard. The Rose Poly team began to tire from the long trip, and the offense did not function well in the second half.

Colwell was high with eight points, and Eckerman was next with five. Hallock was the big gun for Hillsdale with sixteen points.

Summary

The season as far as percentages of wins and losses were concerned could not be considered very successful at first glance. However, the teams that Rose Poly competed with this year are all ranked very high in Indiana Conference circles. In each game the Engineers played good basketball, but the basketball team here at Rose has many serious handicaps to overcome in preparing for the season.

In the first place basketball is just a sideline to the embryo engineers who are here primarily to get an education. In a great many other schools basketball and football players are encouraged by means of scholarships, but Rose athletes learn engineering and play basketball afterwards. Another handicap is the lack of practice time and facilities. Every practice session finds several boys attending late classes, and consequently practice time is diminished. The gymnasium is old, and, while serviceable, it is definitely a contrast to some of the gymnasiums the team plays in. There has been much agitation in recent years for a new gymnasium, but little has resulted from it.

This year Coach Brown developed a real star in Robert "Rosie" Colwell. Rosie is a sophomore and was a member of the team in his freshman year. This season Colwell, a six foot three and one-half inch center, scored a total of 188 points in fourteen games for a game average of thirteen and three-sevenths points. He was second only to Young, All-American star from Purdue in state college basketball.

The members of the team scored as follows:

Colwell	188
Ladson	85
Eckerman	42
Appel	26
Dreher	25
Reel	17
Harper	16
Wolf	16
Egloff	15
Smith	13
Kerns	8
Brittenbach	4

Egloff, Kerns, and Reel were hampered by scholastic difficulties and did not complete the season. White, Forsythe, Hogan, Anderson, and Combs were loyal all season and will undoubtedly have better records after gaining a little experience.

At the conclusion of the playing season major letters and sweaters were awarded to Ed Eckerman, captain, and Wolf, seniors; Smith and Ladson, juniors; Colwell and Appel, sophomores; and Dreher and Harper, freshmen. These men are to be congratulated on the honor they have received.

Basketball Banquet

The end of the season officially arrived with a banquet at Coach Brown's home for the entire squad. The sole objects were to eat as much as possible and then have an enjoyable evening. Both were fully realized. However, everyone ate so much that he could barely navigate, but no one suffered any ill effects. It was a fine banquet and one toward which all basketball players look each year. Captain Ed Eckerman was adjudged the heaviest eater, but Appel and Stanfield, football captain and guest, were just one piece of cake behind.

At this banquet the election for the next year's captain was held. Robert Ladson, member of the team for the past three seasons, was elected. He has the support of the entire squad, and the present members of the team who will be members of the next season's team look forward to a very successful season.

Intramural Basketball

Although the intercollegiate athletic season as far as Rose is concerned is finished, there is an intramural basketball tournament in progress. This was initiated primarily to give boys who were not on the varsity team a chance to play. At the present time seven games have been played. The summary of scores follows:

Seniors 33—Juniors 20.
Soph A-23—Fresh A-20.
Soph B-14—Fresh B-16.
Seniors-14—Soph A-20
Fresh A-33—Juniors-7.
Fresh B-24—Juniors-16.
Seniors-29—Soph B-20.

Each class has one team, and the sophomore and freshmen groups have each been divided into two squads. This selection was made by drawing the names from a hat.

Spring football, a little late this year because of the Rose Show, will start on April 11 and continue for a three weeks period. A spring game between picked squads will be played April 30. At the conclusion of this game the boys will hang up their football clothes until early in September when the real session begins again.

An intramural baseball tournament will begin soon and will be conducted in the same manner as the basketball tournament.

As usual an intramural tennis tournament will be held to pick singles and doubles champions for the school.

Alumni Notes

edited by
Robert S. King, m., '40

Alexander Babillis

Alexander Babillis, Rose '28, was one of the 40 employees cited by the General Electric Company on February 23 for outstanding accomplishments in that company's service during 1937. Mr. Babillis, who is a manufacturing methods man in the equipment planning department of the lightning arrester section of General Electric's Pittsfield plant, received a cash honorarium and a framed certificate bearing this citation: *"In recognition of his foresight and ingenuity in designing and installing radically different cylindrical treating tanks of much greater capacity and increased efficiency."*

The G. E. citations, of which Mr. Babillis' is an example, are provided by the Charles A. Coffin Foundation. This foundation, which originated in 1922, was instituted in honor of Charles A. Coffin, organizer and first president of the General Electric Company. The foundation and the winners of its awards are a tribute to his outstanding work of placing the achievements of engineers and research scientists at the everyday service of the world.

Mr. Babillis, Rose's representative in the ranks of this year's winners of the award, worked for the Pennsylvania Railroad in 1925 and 1926 and, after graduation, joined the General Electric Company as a student engineer, staying on test for approximately a year and one-half. In the latter part of 1929, he joined the Billings and Spencer Company and in January of 1930 returned to General Electric.

Robert G. Laatz

Robert G. Laatz, class of '32, with the Callahan Construction Company, is now on the New York water supply project. The job is to tunnel water from the Delaware River, under the Hudson, and on into New York City—a total distance of 85 miles. It is necessary to sink shafts at various points to accomplish this project. The shafts will be sunk in solid rock and will be fifteen feet in diameter, ranging up to nine hundred forty-five feet in depth.

Mr. Laatz's specific position on this project is that of purchasing agent, which, he informs us, is no snap.

Mr. Laatz now lives in Mahopac, New York, a popular summer resort and the scene of many winter sporting events.

J. T. Hallett

J. T. Hallett, Rose '14, present traffic engineer of the State Highway Commission of Indiana, was elected president of the Indiana Engineering Council at its annual meeting in Indianapolis, February 25th. The Indiana Engineering Council is a state-wide organization composed of engineering groups interested in furthering the profession and assisting in the worthy enterprises of its member groups. Member organizations of the council are Indiana Sections of the American Society of Civil Engineers, American Institute of Electrical Engineers, American Society of Mechanical Engineers, and the Indiana Society of Professional Engineers.

Mr. Hallett, who has been with the Highway Commission since its inception, is one of the founders of the Indiana Society of Professional Engineers.

Weddings

Mr. Arthur C. Keiser was wed to Miss Margaret Kraeger at South Bend, on March 12. Mr. Keiser is a graduate of Rose, class of '28, and is employed in South Bend. The announcement of their engagement appeared in the last issue of the *Technic.*

Announcement is made of the wedding of Burt F. Raynes to Miss Lois Cook, which occurred March 19. Mr. Raynes attended Rose a few years ago and is now connected with the Ryan Aeronautical Company in San Diego, California. Miss Cook is a graduate of DePauw University and was from Terre Haute.

Obituary

Victor K. Hendricks, a former well-known Terre Hautean and a distinguished civil engineer, died March 19 at his home in Oak Park, Illinois. He graduated from Rose in 1889 and soon afterwards became an engineer for the Pennsylvania Railroad. For several years later he held a high executive position on the Denver and Rio Grande Railroad. He is survived by Mrs. Hendricks, his sister, Miss Caroline Hendricks, and two sons, Victor K., Jr., and Ross E. Hendricks.

The funeral was held in Indianapolis, Indiana, at the residence of his sister.

Here and There With The Grads

ex'93 Robert Luke lives in Wheeling, West Virginia, and is with the Wheeling Corrugated Co.

ex'94 Roy Thompson, who now lives in Tacoma, Washington, recently communicated with the Institute after being unheard of for over forty years.

'95 Harrison W. Craver, director of the Engineering Societies Library of New York City, was elected president of the American Library Association at the recent fifty-ninth convention.

'14 Wilbur O'Laughlin, with the U. S. Housing Authority, is stationed at Evansville.

'20 Herbert Sliger, with Commercial Solvents, has been transferred to New York, where he is to be district sales manager.

'21 William H. Merry is ceramic engineer for the National Sanitary Company of Salem, Ohio.

'22 Robert P. Failing, with the Barrett Company, has been transferred to Detroit, where he is chief engineer.

'32 Clifton A. Pratt is now in the engineering and inspection division of the Traveler's Insurance Company and is located in Chicago.

'33 Dan Ringo is with the M. W. Kellogg Company of New York City, manufacturers of oil refinery equipment.

'35 Louis S. Lyon is employed by the American Tobacco Company in Terre Haute.

'36 Harry E. Garmong, with Carnegie-Illinois, is taking several courses in metallurgy at Chicago University.

'37 Robert A. Averitt, with the General Electric Company, has been transferred to Fort Wayne.

Fraternity Notes

Sigma Nu

The Beta Upsilon chapter held its annual pledge dance in the fraternity house. Leo Baxter and his orchestra furnished the music. The house was decorated in white, black, and gold, the fraternity colors.

General chairman Wayne Alexander was assisted by the following committees: Charles Fuller and Richard Weldele, chaperones; Joseph Dillahunt and Paul Stark, orchestra; Charles Drieke, Richard Mullins, David Huggins, Raymond Chausse, and Robert McKee, decorations.

Chaperones for the dance were Mr. and Mrs. J. Page Wheeler and Mr. and Mrs. Fred Nicoson. Several alumni also returned for the dance.

Theta Xi

On March 17 Kappa chapter held a dinner meeting at the Stevens Restaurant on South Seventh Street. This was first of several dinner meetings to be held once a month. The meeting was well attended by the members as well as by several alumni.

The pledge dance held in the Edgewood Cabin, was one of the high spots of the month on the social calander of the chapter. It was an Engineer's dance, the boys wearing school clothes and the girls wearing print dresses. Refreshments were abundant in the form of root beer and pretzels and with cokes for the teetotalers. Everyone had a good time, and the affair proved to be a huge success. The chaperones were Professor and Mrs. H. C. Gray, and Professor and Mrs. J. L. Bloxsome.

A formal initiation was held early Sunday morning, April 3. This was a special ceremony for the holdover pledges. Those initiated were Milton Hosack, Robert King, James Lohr, and Walter Zehnder. Initiation for the new pledges will be held at a later date.

The Terre Haute Theta Xi Alumni Association has been quite active in helping with the chapter at Rose. Mr. Don Gardner is a recent addition to the ranks of the loyal supporters. He has recently arrived from the west coast, and we wish to thank him for his enthusiasm toward drawing the alumni and the active chapter closer together.

Alpha Tau Omega

Thursday, March 24, was Founder's Day for Alpha Tau Omega and was celebrated by a joint banquet of A.T.O. alumni of Terre Haute and active members. The affair took place in the Dutch Room of the Elks Club and was enlivened by an inspiring talk by Mr. Mort Hayman. At the election of officers, Dr. Paul Zwerner became president of the Terre Haute A.T.O. Alumni Association. Prospects of future dinners at the chapter house for members and alumni were discussed.

At a recent assembly Brother James Ducey received an award which is probably the greatest honor available to underclassmen. This award was an engineer's handbook presented by Tau Beta Pi fraternity. It is given each year to the sophomore who has made the greatest increase in his scholastic average during the previous school year.

The informal aspects of the A.T.O. social season undoubtedly reached its climax Saturday, March 26, when the chapter had a kid-party open house. Kid's clothes were required for admission and jacks, hop-scotch, and jump-the-rope were the major amusements. Miss Helen Mahley took first honors in hop-scotch. Lollypops and toys added to the proper atmosphere. Chaperones for the occasion were Mr. and Mrs. John Phelps, Miss Helen Mahley and Captain F. E. Henney.

The chapter is proud to announce that Mert Scharenberg has been awarded the Thomas Arkle Clark award for the state of Indiana. This award, based on several points, has as its significance the fact that its recipient is the outstanding senior A.T.O. in the state.

Theta Kappa Nu

On Friday night, March 25, the members of Theta Kappa Nu fraternity and several other fellows from school went on a hay ride party in Illinois. Although the weather was bad and the ground muddy, everyone had a lot of fun and a good time. An especially enjoyable occasion presented itself when the horses were unable to pull the wagon up one of the hills, and everyone had to walk to the top of the hill in mud and water.

A fire was built in a large woods with coal-oil, corn cobs, and wet wood. After a few futile attempts, it was finally kindled. The taste of smoked weiners, hot coffee, and toasted marshmallows was very delicious.

The fellows wish to express their appreciation to Buzz Montgomery who made all the arrangements.

Humor

edited by

James E. Ducey,
ch., '40

Hotel Manager: "Sorry, you'll have to clean the mud off your shoes before registering."

Eudaley (from Kentucky): "What shoes?"

The following conversation ensued between a hungry Irishman and a restaurant waiter one Friday:

"Have yez any whale?"

"No."

"Have yez any shark?"

"No."

"Have yez any jellyfish?"

"No."

"Have yez any swordfish?"

"No."

"Then bring me ham and eggs and a beefsteak smothered with onions. The Lord knows that I asked for fish."

—Ark. Engr.

Some girls are like cigarettes: They come in packs, get lit; hang onto your lips; make you puff; go out unexpectedly; leave a bad taste in your mouth, and yet they satisfy.

—Urchin.

And then there's the one about the fellow who was the president of a suspender company. At every banquet he proposed a toast to the law of gravity.

"I hear that John G. knocked out all his teeth."

"That's right."

"How'd he do it?"

"Somebody rolled a nickel under the table."

A CREATION

Blue eyes gaze in mine—vexation.
Soft hand closed in mine—palpitation.
Fair hair brushing mine—expectation.
Red lips close to mine—temptation.
Footsteps—damnation.

—Urchin.

"Do angels have wings, mother?"

"Yes, they do, dear."

"Then why doesn't nursie fly? I heard daddy call her an angel."

"She will in the morning, darling."

—Michigan Technic.

A cute little trick from St. Paul
Wore a "newspaper dress" to a ball.
The dress caught on fire
And burned her entire
Front page, sporting-section and all.

—Mis-A-Sip.

Boy: "Hello."

Girl:

Boy: "Oh, well."

—The Pointer

"Where were you born?"

"In a hospital."

"No kiddin'? What was the matter with you?"

A BARGAIN

The abstracted lady with the parasol strolled across the green and stooped to pick a clover.

"Fore!" yelled a golfer impatiently. There was no move.

"Fore!" he tried again, louder.

"Try her at three ninety-eight," advised his partner.

And the Germans named their ships after jokes so the English wouldn't see them.

Taxi driver: "I take the next turn, don't I?"

Voice from rear seat: "Oh Yeah!"

—Nebraska Blue Print.

Drunk to skunk: "Nic-e kitty. Nic-e kitty. Shay what have you been drinking?"

—Penn Triangle.

On a street-car a man gave his seat to a woman. She fainted. On recovering she thanked him. Then he fainted.

Voice over phone: "Pop, guess who got kicked out of college!"

—Exchange.

Irate old lady on a rainy day: "It's the likes of you that makes the highways dangerous. Fancy! Dulling the point of my umbrella with your glass eye."

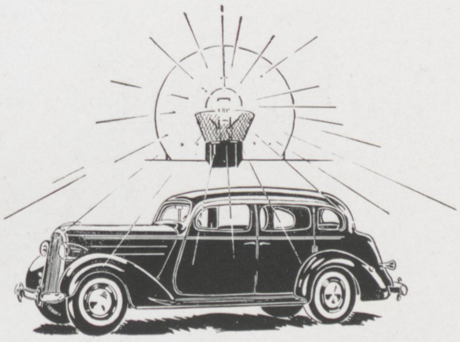
A young theologian named Fiddle
Refused to accept his degree,
"For," said he, "it's enough to be Fiddle,
"Without being Fiddle, D.D."

Panhandler: "Say, buddy, could you let me have a buck for a cup of coffee?"

Gent: "A dollar for coffee? Preposterous!"

Panhandler: "Just tell me yes or no—but don't try to tell me how to run my own business."

G-E Campus News



18 INCHES OF SUNLIGHT

A 50,000-WATT General Electric MAZDA lamp, a foot and a half in diameter, was recently installed in the Styling Section of the General Motors Corporation at Detroit. This lamp, the first of its size to be used commercially, is utilized to simulate sunlight on automobiles on display. Previous lighting not only was inadequate, but produced distracting reflections on the car bodies.

By means of a G-E thyratron reactor control similar to devices used to dim lights in many large theaters, the light from the lamp can be varied from full brilliance to a black-out.

Many such practical applications as this are the culmination of group effort. That is why General Electric Test men of today and yesterday are always to be found contributing their part to General Electric's progress.

FOR OUTSTANDING ACHIEVEMENT

EACH year General Electric honors those employees who have done outstanding work in their fields as provided in the Charles A. Coffin Foundation. This year 40 men were chosen—15 of them college graduates:

Adelbert Alexay, Polytechnic Institute of Budapest, '11; *Alexander Babillis, Rose Polytechnic Institute, '28; *T. M. Berry, Kansas State College, '27; Michael Broverman, Tri-State College, '22; F. E. Carlson, University of Michigan, '25; *S. B. Crary, Michigan State College, '27; R. E. Farnham, Case School of Applied Science, '17; J. W. Gilchrest, Cooper Union, '08; *A. H. Lauder, University of Wyoming, '22; *Domenico Martignone, Central Technical College of London, '01; *F. N. Neal, University of Utah, '31; *D. R. Shoults, University of Idaho, '25; F. C. Smith, Drexel Institute, '06; *L. A. Umansky, Polytechnical Institute of Petrograd, '15; R. E. Worstell, Purdue University, '25.

If any one generalization could be made to cover the qualifications for this award, it would probably hinge upon the extent to which an employee took advantage of his opportunities, beyond the ordinary routine of his work to achieve an outstandingly worth-while result.

**Former G-E Test man*

LIGHTNING GUIDER

AFTER three years of photographing natural lightning striking the Empire State Building in New York City, it was determined that many lightning strokes which appear to crash from the clouds to the ground actually are met part way by a small flash, originating from the earth, which guides the stroke to its destination.

In addition, laboratory tests, under the direction of Karl B. McEachron, graduate of Purdue University and former G-E Test man, indicate that discharges between points and planes always begin at the point. The Empire State represents to the cloud a tremendous needle on the earth's surface. Thus the guiding flash will originate from the tower and shoot upward.

Destruction occurs when a lightning bolt contacts a high-resistance area. Lightning conductors prevent this by grounding the discharge in an area of low ground resistance, and the lightning control on the Empire State affords a protective area within a radius of approximately one mile.

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